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VOL. 22 MAY, 1930 No. 5

A SUMMARIZATION OF EXPERIENCE AND CURRENT PRACTICE IN CERTAIN PHASES OF STEEL PLATE PIPE LINE CONSTRUCTION[1]

As a first step in the gathering of data for the use of the proposed Sub-Committee No. 7-A on "Steel Plate Pipe," a memorandum was circulated in the spring of 1929 among some 16 water works engineers, each of whom has in recent years been responsible for the installation of large steel plate pipe lines east of the Rocky Mountains, with the request that each prepare a monograph concisely covering his own experience, current practice, and present judgment regarding moot points.

Eight of these gentlemen responded as follows:

George H. Fenkell, General Manager, Department of Water Supply, Detroit, Michigan.

William E. Foss, Director and Chief Engineer, Water Division, Metropolitan District Commission, Boston, Mass.

George W. Fuller, Fuller and McClintock, Consulting Engineers, New York City.

J. Arthur Jensen, Supervisor, Water Works Department, Minneapolis, Minn.

John F. Laboon, The J. N. Chester Engineers, Pittsburgh, Pa.

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[1] Prepared as part of the work of the Water Works Practice Committee by Committee No. 7 on "Transmission and Distribution of Water." G. Gale Dixon, Chairman. Deputy Chief Engineer, The Mahoning Valley Sanitary District, Youngstown, Ohio.

*E. E. Lanpher, Managing Engineer, Bureau of Water, Pittsburgh, Pa.
Arthur V. Ruggles, Late Engineer of Construction and Surveys, Division of Water, Cleveland, Ohio.
John F. Skinner, Sanitary Engineer, Department of Public Works, Rochester, N. Y.

Several of the monographs were presented in full before the annual convention in Toronto last June; all are here summarized under the several topics which were offered for discussion by the original memorandum.

1. QUALITY OF STEEL

For many years it has been common practice to specify steel of quality and with test procedure conforming quite closely with the present current standard specifications for locomotive "fire-box" or "flange" grade; recently there appears to be a growing tendency toward the use of "structural" grade.

What is your practice in this regard, and upon what experience and observations is it based?

(a) Fenkell—Detroit Water Board.

"Detroit has always used the grade of steel for plates known as Flange."

(b) Foss—Boston Metropolitan District.

"The quality of the steel plates now used is as specified in the standard specifications of the American Society for Testing Materials, 'A 7–24, Structural Steel for Bridges,' for riveted and Lockbar pipes, and 'A 78–27, Steel Plates of Structural Quality for Forge Welding,' Grade 'A' for Electric Welded pipes.

"There is a supposition that better material and more care are used in making boiler and firebox steel for locomotives, (A. S. T. M. Serial Designation A 30–24), but for pipe line construction these slight advantages did not seem to warrant the payment of the higher price charged for this steel.

"No trouble which could be laid to the quality of the steel has been experienced in the fabrication of the pipe at the shop or in the field work.

"Grade A 'Steel Plates of Structural Quality for Forge Welding' (A. S. T. M. Serial Designation A 78–27), were adopted for pipe lines with electric welded longitudinal seams after conferences with welding engineers of the Westinghouse Electric and Manufacturing Company and of the General Electric Company. This steel has greater ductility than the other steels and is believed to be more suitable for welding."

---

*Since deceased.

(c) Fuller—Fuller and McClintock.

"Fire box steel, Flange Quality, Serial Designation A 30–24 of the American Society for Testing Materials, is called for on specifications for the plates for steel pipe. We believe that the greater ductility of the steel is of sufficient advantage in making up field joints to more than compensate for its extra cost."

(d) Jensen—Minneapolis Water Department.

"The earliest pipe was 'soft steel,' having the characteristics of fire box steel. The last line was of 'flange' grade. The soft steel stands up well in this locality. We feel that 'structural' grade may not be as durable."

(e) Laboon—The J. N. Chester Engineers.

"It has been our practice to use soft steel plates made by the basic open-hearth process with limited percentages of phosphorous, sulphur and manganese. The extra cost of locomotive 'fire box' or 'flange grade' in our experience cannot be justified."

(f) Lanpher—Pittsburgh Water Department.

"For riveted and 'lock-bar' pipe, Pittsburgh uses steel conforming generally with the requirements of the A. S. T. M. specifications for 'Structural Steel for Bridges,' (Serial Designation A 7–24), with the added requirement that the manganese content shall not exceed 0.5 percent.

"For hammer-welded pipe, 'Steel Plates of Structural Quality for Welding, Grade A,' (A. S. T. M. Serial Designation A 78–27), are used."

(g) Ruggles—Late of Cleveland Water Department.

"From specifications for Contracts 11 and 15, City of Cleveland, Baldwin-Fairmount project, furnishing and laying about 4 miles of 60-inch steel pipe:

"*Riveted Steel Pipe.* For plates, Flange Steel, A. S. T. M. Standard specifications for Boiler and Fire-box Steel for Locomotives, A 30–18. For rivets, A. S. T. M. Standard specifications for Boiler Rivet Steel, A 31–14.

"*Lock Bar Steel Pipe.* Plates and rivets same as under Riveted Steel Pipe. 'Lock bars shall be made from extra dead soft, open hearth steel with an ultimate tensile strength of from 40,000 to 50,000 pounds per square inch.'

"*Hammer Welded Steel Pipe.* For plates, A. S. T. M. Standard specifications for Forge Welding Steel, A 78–21T. Rivets same as under riveted steel pipe."

(h) Skinner—Rochester Water Department.

Specification requirements are tabulated below:

	CONDUIT NO. II	CONDUIT NO. III
Constructed in	1893	1914–1918
Size of pipe, inches	38	37
Length, miles	25.93	17.75
General quality of steel	"Soft Open Hearth"	"Soft Open Hearth"
Manganese, percent	Not more than 0.6	0.3 to 0.5
Suphur, percent	Not more than 0.06	Not more than 0.05
Phosphorous, percent	Not more than 0.06	Not more than 0.05
Silicon, percent		Not more than 0.04
Tensile strength	55,000 to 65,000	52,000 to 62,000
Elastic limit	Not less than 35,000	Not less than 30,000
Elongation—thickness of plate:		
⅝-inch	25%	
Less than ⅝-inch	22½%	
¼-inch		25%
Reduction of area		50%
Bend—test pieces 6 inches by 1 inch bent cold 180° and hammered flat without sign of fracture		

2. MILL INSPECTION OF BOTH SIDES OF PLATE

It seems elementary good sense to inspect both sides of all plates at the mill, and some specifications require it. Many mills, however, are not equipped for the safe and expeditious handling of plate for this purpose, and object to the requirement on the ground that the purchaser is fully protected by the ordinary provision for rejection at the shop if defects are there found.

What is your experience?

(a) Fenkell—Detroit Water Board.

"It is our belief from information received from the testing laboratories that on mill inspection, the inspector gets a chance to see but one side of the plate."

(b) Foss—Boston Metropolitan District.

"Experience indicates that if the inspection of both sides of the plates at the mill entails very much expense, it is not warranted, as

laminations, lumps of mill scale, or of steel rolled into the plates, are often hidden by the surface scale and do not show up until the plates are fabricated at the shop. At the Homestead Mill near Pittsburgh, plates are inspected by first examining the top surface. The plate is then lifted about 6 feet high in a horizontal position and the bottom surface is examined by means of powerful lights with reflectors attached to long handles so that every part of the plate can be examined without getting under it."

(c) Fuller—Fuller and McClintock.

"If possible, plates should be inspected on both sides at the mill."

(d) Lanpher—Pittsburgh Water Department.

"We do not inspect plates at the mill on both sides unless the mill is especially equipped. We do, however, inspect the plates carefully on both sides in the fabrication shop."

(e) Laboon—The J. N. Chester Engineers.

"It is well to inspect both sides of all plates at the mills. On the other hand, it is impractical in some cases to demand it. Ordinarily shop inspection would discover any defects on either side of the plate, and thus a careful man on shop inspection would render mill inspection less important."

3. SPECIAL QUALITY OF METAL

Have you had any experience with the use of special quality of metal, such as "Ingot Iron" or "Toncan Iron," which would afford any knowledge as to value in corrosion resistance as compared to steel?

(a) Fenkell—Detroit Water Board.

"Detroit has had no experience wih Armco or Toncan iron plates, but receives proposals on pipes made of these metals and allows a differential of ten years longer life than steel plates in evaluated bids."

(b) Lanpher—Pittsburgh Water Department.

"We have had no experience with Ingot iron or Toncan iron in actual practice.

"Specifications permit competition between soft steel and ingot iron."

(c) Ruggles—Late of Cleveland Water Department.

"Examples of old wrought iron water mains which have resisted corrosion from water or from water and soil better than have steel pipe under identical conditions are:

"Forty-inch wrought iron line in the St. Clair Avenue tunnel under the Cuyahoga River at Cleveland, laid in 1890–1891. Being laid in a brick-lined tunnel, the pipe line is examined throughout occasionally. It is always damp in the tunnel and considerable pitting has taken place, but less than has occurred in the 48-inch steel pipe lines similarly laid in brick-lined tunnels under the river

at Clark Avenue (1895), Main Avenue (1896–1897) and Superior Avenue (1897–1898). I examined the outside of these lines a few years ago when they were being cleaned and painted with water in them.

"The original Cleveland water intake, a 54-inch wrought iron line laid about 1855, abandoned in the 70's, part of which was dug up, on shore, when the West 58th Street Sewage Disposal Plant was built, about 1915."

(d) Skinner—Rochester Water Department.

"In 1874, four 12-inch wrought iron pipes each 163 feet long were laid in charcoal in cast iron and masonry boxes. In the same year 3500 feet of No. 7 B. W. G. (about $\frac{3}{16}$ inch thick), 24-inch wrought iron plate pipe was laid.

"Conduit I, constructed in 1873–1874, was composed in part of 12.67 miles of 36- and 24-inch wrought iron pipe of the class known as 'C No. 1 Shell Iron.' The pipe was No. 7 B. W. G. The end joints at 27.5 feet intervals were hub and spigot lead joints composed of cast iron hubs and in some cases cast iron spigots riveted onto the pipe.

"All of these pipe lines are still in use, with the exception of the 3500 feet of 24-inch pipe which was abandoned in 1924."

4. THICKNESS OF PLATE

Early standards provided a thickness of metal sufficient to hold within desired limits the net tensile stress resulting from internal pressure, with a further allowance of $\frac{1}{16}$-inch for corrosion, and with limits of allowable depth of blackfill over pipe of given diameter and thickness.

In recent years, a good deal of large work has been done with an arbitrary minimum plate thickness of $\frac{3}{8}$-inch, and some of $\frac{1}{2}$-inch.

What is your point of view?

(a) Fenkell—Detroit Water Board.

"Detroit has adopted a minimum thickness of plate of $\frac{1}{2}$-inch believing that the additional thickness insures longer life from outside corrosion or pitting by electrolysis."

(b) Foss—Boston Metropolitan District.

"It has been found that pipes 60 inches or less in diameter with double riveted longitudinal seams and designed with the ordinary factor of safety of 5 to withstand a pressure of 70 pounds per square inch and an allowance of $\frac{1}{16}$ of an inch for corrosion are too thin for practical use, as they lack the desired stiffness and strength to withstand the earth pressures and abnormal strains due to unequal settlement or accidental conditions. The corrosive effect of the soil in which the pipe is laid and of the water to be conveyed require very careful consideration in determining the thickness, and pipe

lines laid in highly corrosive soil or conveying water containing considerable organic acid or that is highly chlorinated should be made of thicker plates than pipe lines laid in non-corrosive soil conveying non-corrosive water, if it is desirable that the pipe lines subject to unfavorable conditions should have as long life as the pipe lines subject to favorable conditions. The steel pipes for the Metropolitan Water Works are being designed on this basis and the thickness of the plates used is, therefore, not based entirely on tensile strength of the metal, a fixed factor of safety and uniform allowance for corrosion."

(c) Fuller—Fuller and McClintock.

"In general it is good practice to figure the thickness of plate required using the factor of safety desired, add $\frac{1}{16}$-inch allowance for corrosion, but hold to the $\frac{3}{8}$-inch minimum for plate thickness for pipes 48 inches and less in diameter, $\frac{7}{16}$-inch for 48- to 72-inch, and $\frac{1}{2}$-inch for larger. Special consideration should, however, be given to cases where the pipe will not be readily accessible where laid under pavements, and care must be used in allowing for water hammer."

(d) Jensen—Minneapolis Water Department.

"The tendency to increase thickness appears to be good practice. Ordinarily steel pipe is in competition as to price with cast iron and reinforced or cylinder concrete. The variation in price is a considerable item. The choice is usually in the interest of economy or first cost. The margin usually permits consideration of life of the pipe. The coatings are somewhat of a problem so far as prolonged life is concerned, but certainly the thickness is not. It seems that an increment in the thickness is a splendid investment. The relative increase in cost is small. We believe that a $\frac{3}{8}$-inch minimum could be considered good practice."

(e) Laboon—The J. N. Chester Engineers.

"It has been our practice to add not less than $\frac{1}{16}$-inch for corrosion, and in some cases, it has been as much as $\frac{1}{8}$-inch. We have used $\frac{5}{16}$-inch plate on 30-inch lines at pressures of 100 pounds, although on occasion we have reduced this thickness to $\frac{1}{4}$-inch, where the pressure has been 50 pounds and less. Of course, depth of backfill has material bearing on the thickness of pipe.

"Special conditions, such as the laying of steel pipe under permanent pavement and the guarding against collapse due to the emptying of the line, must be taken care of in the design."

(f) Lanpher—Pittsburgh Water Department.

"It is our practice to add extra thickness for corrosion purposes. This varies with different soils—being as much as $\frac{1}{8}$-inch in certain cases. We further establish a minimum of $\frac{3}{8}$-inch in thickness for structural reasons."

(g) Ruggles—Late of Cleveland Water Department.

"The 60-inch steel raw water mains at Cleveland were made $\frac{7}{16}$-inch thick throughout their length, thicker than required by the

internal pressure after adding $\frac{1}{16}$-inch for rust allowance. The thickness used was 'that which in general was required by the external loads, due either to traffic in addition to the normal 3 feet depth of cover in streets and park drives,' or 'elsewhere to extra depth of cover over pipe;' stretches where thinner pipe was permissible were so short that no change in thickness was used."

5. CLEANING PIPE

Important installations have been made under specifications calling for cleaning by: (*a*) Pickling; (*b*) sand blasting; (*c*) power-driven brushes; (*d*) specific method not stated.

(a) Fenkell—Detroit Water Board.

"The pickling provision was removed from specifications as experience seemed to indicate that dipped coating did not adhere as well to the pickled plates.

"Sand blasting has not been required, but is allowed if the fabricator desires.

"Wire brushing is required if necessary to make the plate properly clean."

(b) Foss—Boston Metropolitan District.

"The present practice is to clean the pipes with power brushes.

"Cleaning pipes by pickling was considered, but was not adopted on the Metropolitan Water Works because it was believed to be impractical to carry out the process in a satisfactory manner in the shop, and be sure that the acid was completely neutralized, that the protective coating was immediately applied before the rapid corrosion of the pipe metal which follows pickling occurred, and that the process would not prevent a satisfactory adherence of the coating to the metal.

"The cleaning of steel plates of standpipes by sand blast before painting with red lead has also given very satisfactory results."

(c) Fuller—Fuller and McClintock.

"We do not favor pickling due to the uncertainty of perfectly removing all acid, and believe that a better average result can be obtained by mechanical cleaning.

"Sand blasting gives a very clean plate, but this method is slow and expensive.

"Power brushes have a more uniform working pressure than long handled hand brushes and therefore give more uniform results.

"Hard, tight mill scale which has withstood the steel brushes will, in all probability, continue to remain fast to the plate after the pipe is coated.

"If the pipe has been treated with acid, and this hard scale still remains, the dilute alkali may not be able to remove all the acid that has eaten its way into or under the scale; but if the pickling process is not used this tight scale will remain tight after the coating has been applied, and will not be detrimental to the pipe."

(d) Jensen—Minneapolis Water Department.

"Some of our oldest pipe when brought to light shows the original color of the mill scale. If this oxidized surface has any merit in resistance to corrosion, as some believe, its value in our pipe is demonstrated. From this it would appear that any cleaning of plate should not be too severe. Would suggest light sand blast or power driven brushing as being sufficient."

(e) Laboon—The J. N. Chester Engineers.

"It is our experience that ordinarily scale will be loosened and forced off in the fabrication of the pipe, especially when smaller sizes are used, such as 30-inch for example. The tight mill scale, if it does not come off during fabrication, we believe is not objectionable, as it has been observed that sand blasting or power driven brushes have a hard time taking off such scale, and that the pipe metal adjoining the mill scale has been materially worn while the tight mill scale was being taken off. The additional cost of pickling and such methods and the question of obtaining perfect neutralizing action under ordinary circumstances has been sufficiently great to warrant our using such processes only under special conditions."

(f) Lanpher—Pittsburgh Water Department.

"The Pittsburgh specifications do not specify the method of cleaning plates. It does, however, specify very carefully the results to be obtained. It is our experience that the scale is loosened during the process of fabrication, and the rust where it forms, can be removed by wire brushing.

"In the matter of tight mill scale, we do not consider it dangerous."

(g) Skinner—Rochester Water Department.

"After the fabrication, lock-bar pipe for Conduit III were brushed with wire brushes and scraped with steel scrapers, where required to remove all loose scale and rust."

6. COATING

The old "Angus Smith Coating" appears to have assumed a legendary character of excellence unattainable under present manufacturing conditions. Dipping with "Mineral Rubber," asphalt and coal tar, brushing on of hot coal tar and oil paints, have been tried with varying success.

(a) Dixon—The Mahoning Valley Sanitary District.

A statement of the practice in coating of steel plate pipe which has been adopted in the water supply works of the Mahoning Valley Sanitary District may be of interest.

The project includes duplicate steel force mains 36 inches in diameter and each 5 miles in length conveying water to a distributing reservoir in the City of Youngstown, and two steel feeder mains 42 inches in diameter and each about 2½ miles in length leading

from the distributing reservoir to the heart of the city. Pipe with electrically welded longitudinal seams is being used.

There is no reason in this instance to expect serious corrosion either from soil conditions or from stray current, but in the light of experience with the corrosion of steel pipe at Akron and a general knowledge of similar experiences elsewhere, the writer felt it wise to provide for the bulk of the work a better external protection than is afforded by the common dipped coating. Accordingly, the contracts for these pipe lines provide for the use of a "special wrapped coating" to be applied to the pipe in addition to the ordinary dipped coating, over about half of the length of the force mains including all portions of the line where the ground may be expected to be wet, and the entire length of the feeder mains, which are located generally in city streets.

The "special wrapped coating" is applied as follows:

After the dipped coating has been applied and has hardened sufficiently to prevent flow in the subsequent operations, the pipe is wrapped with 7 ounce "Osnaburg" cotton fabric (A. S. T. M, Serial Designation D 205-27), saturated with and carrying an excess of hot Hermastic Pipe Coating or equal. The fabric is wound spirally in 20-inch strips by machine, giving lap of not less than 1-inch, under tension sufficient to cause the fabric to lie snug to the pipe, but not enough to strain or tear it. Each end is finished off with a square wind at a sufficient distance from the end of the pipe to leave the rivet holes accessible and not interfere with the making of field joints.

Field joints are similarly treated, with 6-inch lap over the ends of the shop wrapping, upon the completion of riveting, calking and testing of the pipe in the trench.

Two points of importance are to be noted in this procedure:

First—"Osnaburg" cotton fabric was selected after experiment with about a dozen different materials. Earlier attempts at similar procedure in the east with which the writer is familiar have been based on the use of burlap; this fabric is too dense to permit proper penetration of the hot bituminous material, and carries so much residual vegetable oil that the bitumen will neither saturate nor adhere to the thread.

Second—As wrapped on the pipe, the fabric *is saturated with and carries an excess* of the hot bituminous material. The excess is carried in such quantity that the finished surface is smooth, with the weave of the fabric substantially obliterated.

This "special wrapped coating" results in a heavy second hot bituminous coating, thoroughly bonded to the original dipped coating, and reinforced by a stout loose-weave fabric embedded within it. The contract cost on the current work is $0.08 per square foot.

(b) Fenkell—Detroit Water Board.

"The general practice in Detroit has been to require Hermastic dipped coating or equal. Should the fabricator be unable to meet this requirement because he has no dipping tank, he has been allowed to use a Bitumastic coating brushed on. On one job of 7- and 8-feet diameter pipes, bitumastic coating was specified."

(c) Foss—Boston Metropolitan District.

"The present practice is to clean the pipes with power brushes and coat them by dipping in vertical tanks containing hot coal tar or asphaltum material. Accurate temperature control is essential in this process to obtain satisfactory coating, especially for the coal tar material. With the modern dipping tanks, equipped with electric heating units, it is possible to maintain the coating material at the desired uniform temperature from top to bottom. Pipes coated with coal tar are not preheated, but are kept in the dipping tank long enough for the steel to become heated to the temperature of the coating."

(d) Fuller—Fuller and McClintock.

"In general we favor dipping pipe to apply coating as it seems to be the only practical way to get a really smooth job. For the dipping process we believe in an asphalt base."

(e) Jensen—Minneapolis Water Department.

"Pipe coating is probably one of the most uncertain of the remedies against surface corrosion. A hot dip with the material literally 'burned' into the plate is no doubt the best method of application. If the pipe could be placed in the trench as they come from the dipping tanks much grief can be avoided. The pipe coating however suffers in handling, is laid bare where contact is made even in padded pillow blocks, and is subjected to damage along the line of construction. Field patching is never satisfactory, because it is difficult to get the patches clean or to make an application that is ever as good as the original. Likewise the joints can never be made as good as the rest of the surfaces of the pipe. We have tried burlap wrapping and find that this rots and the coating flakes off in large pieces. Coatings on the inside deteriorate under long time contact with the water which ultimately comes in contact with the metal and tuberculation begins. The oils break down and the coating becomes a crumbling residue.

"More coal tar pitch and less asphalt is perhaps the best tendency, though this gives a more brittle coating. If it can be put in place it will probably be the most durable.

"If a soil and carried water is conducive to long life of the metal, we are of the opinion that an extra unit of metal thickness is more to be desired than too much confidence in the coatings. Coatings at best are not as long lived as the pipe line itself and can be relied on only as an initial protection.

"Some of the rubberoid spiral wrapped pipe in conjunction with a good coating material is very attractive for outside protection.

We feel, however, that the extra cost of this should be weighed carefully against an investment for an extra unit of thickness of plate.

"It might be added that the coating of our thirty-two-year-old lines was the so-called 'mineral rubber' asphalt the base of which was Utah Gilsonite. This was prepared after much investigation and appears to have some merits. Our outside men pronounce it the best coating that has been used on steel. This is, of course, according to their observation."

(f) Laboon—The J. N. Chester Engineers.

"We prefer a dipped coating of an asphalt base with minimum thickness of $\frac{1}{32}$-inch."

(g) Lanpher—Pittsburgh Water Department.

"Pittsburgh requires a coating of steel pipe by the hot dipping method in a bath of 'Ovarco Pipe Coating' or equal, at a temperature of 420°F., and in case the coating shall be less than $\frac{1}{32}$-inch in thickness, or shows bubbles or pin holes, the pipe is redipped.

"This Ovarco Pipe Coating is practically the same as Pioneer Mineral Rubber Coating, which has been in service on some of the steel pipes for over thirty-five years."

(h) Skinner—Rochester Water Department.

"The 24-inch wrought iron pipe laid in 1874 was said to have been coated with 'Boiler Maker's Black Paint.'

"The steel pipe in Conduit I was coated with a hot dip of 'asphaltum and coal tar' (free from oily substances).

"On Conduit II three different hot dips were used, as follows:

"California asphalt fluxed with Maltha on about 30 percent of the line; Trinidad Asphalt and coal tar pitch on about 20 percent of the line; Sabin's 'Baked Japan' on about 50 percent of the line.

"The coating for pipe in Conduit III was radically different from that of Conduit II, and consisted of a shop coat of the Detroit Graphite Company's graphite paint No. 501, in which the pigment consisted largely of red lead and amorphous graphite. The vehicle consisted of raw linseed oil. This coat was applied by hand inside and outside of the pipe at the shop, and in the field abraded portions were touched up with the same paint. After drying, a second coat of Superior Graphite No. 106 was applied. This consisted of ingredients similar to the first coat, but in somewhat different proportions. It was of a different color, which aided inspection. This was followed by a protective coating of the Truscon Laboratories's 'Bar-Ox,' which was used mainly to prevent abrasion of the former coatings during handling of the pipe and backfilling of the trench."

7. CORROSION EXPERIENCE

Salt marsh, the strongly alkali soils of the west, and acid mine waters we know to be violently corrosive; the concentrated discharge

of stray current from a steel pipe line near a power house has been known to cut through $\frac{3}{8}$-inch plate in ninety days.

What of the wide border-land of mildly corrosive conditions? Soil corrosion is attributed with responsibility for localized perforation of the Rochester steel pipe in about five years; mild stray current with favorable ground conditions achieved the same result at Akron at a distance of three miles from the trolley line. Similar conditions in varying degree of importance have been found elsewhere.

What have you observed? Is hard, tight mill scale to be considered dangerous? Can poor foundry practice be responsible for any of the corrosion troubles you may have experienced? What of internal corrosion or the lack of it—as regards both tuberculation and perforation?

(a) Fenkell—Detroit Water Board.

"Our experience with steel pipe has been of such short duration that we have no definite information regarding corrosion in the local soils."

(b) Foss—Boston Metropolitan District.

"The steel pipe lines across the Sudbury River and Happy Hollow Valleys on the line of the Western Aqueduct have been in continuous service since December, 1903. They are 90 inches in diameter and were made of soft, open hearth steel plates, $\frac{7}{16}$-inch in thickness. A mineral rubber pipe coating was used for these pipes. The pipe lines were inspected on the inside in June, 1908, and again in November, 1920, and on the outside at three test pits in April, 1928. In connection with the interior inspections, measurements were made of the depth of corrosive pittings with a micrometer depth gage and including the thickness of the coating, which varied from 0.015 to 0.04 of an inch, the total depths in inches were as follows:

	DATE OF INSPECTION	DEPTH OF PITTINGS		
		Maximum	Minimum	Average
		inches	*inches*	*inches*
Happy Hollow Pipe Line	1908	0.097	0.050	0.067
	1920	0.160	0.080	0.127
Sudbury River Pipe Line	1908	0.090	0.045	0.073
	1920	0.210	0.090	0.148

"In 1920 the coating showed numerous blisters filled with water, but the steel under the blisters was not rusted. There were also a large number of rust tubercles and under each tubercle a pitting. The coating appeared to be in poor condition and very near the end of its useful life.

"In 1928 the outside of the pipe was found in almost perfect condition with very little rust and no pitting of any measurable depth. The coating was in poor condition but better than on the inside of the pipe. The soil was dry, silicious sand and gravel."

(c) Fuller—Fuller and McClintock.

"One factor that is often overlooked when tests are being made of the soil through which steel pipe is to be laid is the type of equipment to be used in excavating, laying the pipe and backfilling. If coal burning equipment is used, great care must be used to keep all cinders away from the pipe and not allow the cinders to be used in the backfill."

(d) Jensen—Minneapolis Water Department.

"In this locality soil conditions are favorable to long life of steel. High ground, whether sandy or clay soils, are neutral. The whole region is glacial moraine deposit, and is thoroughly washed out leaving only the clean debris from prehistoric glacial actions. In marshy pockets saturated with steeped vegetable matter, the soil in some cases is 'sour.' This might affect the pipe, but only in such local cases. We usually back-fill and cover the pipe with clean sand. This, of course, does not prevent penetration by ground waters, but the peaty soils are not in contact with the pipe.

"The trolley system is thoroughly grounded, due to precautions resulting from legal action years ago, and stray currents are not dangerous except under certain local situations.

"From observation of our lines now thirty-two years old, it appears that tight mill scale is not dangerous. Outside surfaces cleaned off show the original bluish color of the plate.

"Our water carries an alkalinity of from 80 to 200 p.p.m. These lime and magnesia salts obviate a very corrosive water. After filtration the carbon dioxide content is raised, which is not so favorable. Examination of the above lines show rough spots on the interior surface of the pipe, but they are not deep and appear to be only incipient corrosion."

(e) Laboon—The J. N. Chester Engineers.

"In special cases where mine waters have been found to saturate the ground, we have provided a puddle fill around the pipe as added protection. We do not believe that tight mill scale is dangerous, nor that foundry practice can be blamed for much of the corrosion troubles. In our experience we have not as yet found a piece of pipe which has not experienced some tuberculation on the interior."

(f) Lanpher—Pittsburgh Water Department.

"We have experienced no internal corrosion of steel pipes coated with Pioneer Mineral Rubber Coating during thirty-five years of

service. There is one steel pipe so located that drainage from an abandoned mine seeps through the soil around the pipe. This pipe has been in service about thirty years and is still in good condition, and is covered with the same mineral rubber coating. One 50-inch pipe laid through a cinder and slag fill showed serious outside deterioration in fifteen years, and has been covered in some sections with concrete, and in others with a good grade of local clay. In ten years of experience, the deterioration has not progressed in either case.

"In the matter of electrolysis and galvanisis steel pipes suffered considerably in the vicinity of power houses, and particularly where slag or cinders were contained in the soil. This action has not progressed materially since the electrolysis mitigation system was installed nearly twenty years ago. These pipes had, in general, been coated with mineral rubber coating."

(g) Ruggles—Late of Cleveland Water Department.

"The 60-inch steel plate pipe lines constructed in connection with the Baldwin-Fairmount project were located in an area relatively free from the prospect of damage to the lines by stray-current electrolysis, but we felt it wise to go to some expense to prevent or minimize trouble of this kind and incidentally to be able readily to measure conditions of flow in various parts of lines at all times in the future.

"To carry out these purposes, wherever we changed from steel to cast iron pipes, as we did at numerous places, we bonded from steel to steel past the cast iron pipe or fittings with copper wire welded to the steel at each end, and with branch wires running from the main wire to each fitting in the line.

"At occasional points along the lines we ran up from the steel pipe two wires to the surface of the ground about 10 feet apart, terminating at the surface in monument boxes so that measurement of flow of current along the pipe could be made at any time without excavating.

"At other places along the lines where we thought that conditions were such that there was more than average likelihood of current flow transverse to the lines, we built concrete manholes containing three 12-inch square openings in the walls, one between the two pipe lines and the others outside of them, the three holes being in a line at right angles to the pipe lines. This enabled us to go down in such a manhole at any time and stick electrodes through these holes into the earth and see if there was any flow of ground current across the lines.

"We had the copper wire bonding put in for us by the Cleveland Street Railway Company and had the engineers of that company twice a year make a set of measurements at all of these points provided. Latest information to date from the Cleveland Water Department is that no trouble from electrolysis has as yet developed.

"It is my point of view that appreciable expense for provisions such as those explained above is warranted in a steel pipe installation of any magnitude, even though in an area which is considered to be good, as conditions may change in future, and if periodic measurements can be made without excavation, it is a simple and cheap thing to make them and perhaps thereby prevent costly and serious trouble."

(h) Skinner—Rochester Water Department.

"The first leak due to corrosion in the wrought iron pipe of Conduit I occurred in 1894—twenty years after construction of the line—and a total of only 23 such leaks have occurred to date.

"External corrosion of the steel plate pipe of Conduit II has been more serious, requiring the uncovering and repairing of about 8 miles out of the total length of 26 miles of pipe during the thirty-five years that the pipe has been in service. The first leaks due to corrosion occurred about six years after the pipe was laid.

"The first leaks in Conduit III developed in September, 1921, and were apparently due to abrasions of the paint coat. A number of leaks later developed on a portion of the line where it was found that there had been unauthorized thinning of the second coat with turpentine. Most of the pittings through the plate have been in this section of the pipe."

8. TEMPERATURE STRAIN

Some of the early lines were anchored by backfilling a stretch of trench with concrete. Later came the "wing anchorage," designed to transmit the temperature load to the surrounding earth at definite unit load per square foot. Then came the transmission of load around valve settings by the use of reinforcing steel in the valve chamber, and more recently by a riveted structural steel harness built into the valve chamber. It is now the practice in some quarters not to anchor the line, but to provide deep bell fittings at gates with sufficient clearance between the end of the steel spigot and the bottom of the socket to allow the steel line to expand and contract freely.

(a) Fenkell—Detroit Water Board.

"It has been our policy to insert bell end gate valves in the line at intervals of approximately ½ mile and depend upon these joints to take up the temperature movements."

(b) Jensen—Minneapolis Water Department.

"We do not provide any anchorage on the pipe except in exceptional cases where there is sharp curvature or elbows. At valves we use cast iron fittings flanged into the line. These are in pairs and have an 8-inch bell and spigot joint."

(c) Laboon—The J. N. Chester Engineers.

"We have used structural steel harness built into valve chambers as anchorage, but also in addition thereto we have used expansion joints designed for the purpose. These are of the slip type with lead pipe packing."

(d) Lanpher—Pittsburgh Water Department.

"The present practice of the City of Pittsburgh is to omit all anchorages on steel pipes, except in special cases on steep grades, nor do we provide slip joints of any kind. We prefer in this district of comparatively few level places, to break the alignment of pipe either vertically or horizontally, or both, so as to allow very short tangents, and to backfill the trenches with soft material. We have one pipe line over 6 miles long without an expansion joint of any kind, which has been in service since 1898 without breakage, except in one case, where it broke in a short tangent between two stream crossings—both of these stream crossings being thoroughly anchored in concrete."

(e) Ruggles—Late of Cleveland Water Department.

"On the 60-inch steel raw water mains at Cleveland, we used line valves smaller than the line, and lead joints at the valves without tying past."

(f) Skinner—Rochester Water Department.

"Conduit II was designed to take the temperature stresses occasioned by a change of 45° F. The maximum range in temperature of the water since 1880 has been 40° or 5° inside of the limit used in the design of Conduit II.

"The 36-inch flanged gate valves used on Conduit II were bolted to the flanges of the steel pipe. The necks of the gates were made unusually heavy and the gate bodies were heavily ribbed to take the longitudinal stresses which might be transmitted by the pipe. Nevertheless, four of the gates were broken just back of the flange. Two of these gates, No. 4 and No. 9, broke during construction in 1893 and 1894; gate No. 3 broke in December, 1899, and gate No. 5 in September, 1909. Gates No. 4 and No. 5 were on low ground on a long length of pipe between slopes. Gates No. 3 and No. 9 were at high points with the profile sloping from them in both directions. All of the gates broke on top.

"In order to obviate such occurrences in the case of Conduit III, the design included concrete anchorages 50 feet long each side of gate vaults, a cast iron hub and flange piece each side of the flanged gate and a lead joint at the extremity of each of these special castings into the hubs of which the reinforced ends of the steel pipe projected. These hubs were made about twice ordinary depth. They were provided with two lead grooves and the joints were run and caulked twice. By this method the anchorage prevents any appreciable pulling of the pipe from the joint whereas a slight movement may take place without putting undue stress on the castings while at the same time the valve is flanged so that it can be removed in case of needed repairs.

"In 1926, while investigating a leak in Conduit II, it was found that a shop seam had telescoped about 3½ inches. This probably took place during the construction of the line in 1893, thirty-three years before, and during the entire time the conduit had carried water uninterruptedly."

9. LIFE OF STEEL PIPE

This is of course a difficult subject to handle, involving a great number of factors. It is, however, a very important one, and its difficulty makes greater necessity for a clarification of thought upon it.

Citations of experience, and expressions of judgment qualified specifically as to variation in surrounding conditions, would be very valuable.

(a) Fenkell—Detroit Water Board.

"For comparison of bids and evaluation of the same, the life of steel pipe has been assumed as thirty-five years."

(b) Jensen—Minneapolis Water Department.

"Two lines each 3 miles in length, 50 inches in diameter, built in 1897 are now thirty-two years old, and are in excellent condition. From all observations it now appears that these lines should be expected to continue in service for another similar period of time. Certainly the body of the metal is practically intact. The inside is slightly rough in spots, but the structural strength is unimpaired."

(c) Laboon—The J. N. Chester Engineers.

"We have seen pipe in the water system of the City of Pittsburgh taken up after almost thirty years of service, which pipe showed some tuberculation on the interior, but very little rusting on the exterior, for which an additional life of thirty or forty years would not be too great."

(d) Lanpher—Pittsburgh Water Department.

"While we consider a life of fifty years for pipe made of soft steel plates to be a fair average, it is evident that Pittsburgh will get a far greater life out of some of its steel mains."

THE CONTROVERSY ON THE USE OF WATER FROM THE ARKANSAS RIVER[1]

By C. L. Patterson[2]

The controversy between water users along the Arkansas River in Colorado and Kansas has been before the courts for about 30 years. The writer has been connected with the study of the physical facts surrounding that valley for 20 years.

In those investigations it has been necessary to collect and study facts in relation to the tendency governing court opinions. This coöperative investigation, in which the legal as well as engineering phases are necessarily blended, has been of great interest and has disclosed how natural and economic forces bear upon custom, and how custom so moulded finally becomes the established and recognized law of the land.

So far as the strictly legal matters are concerned, this discussion should be led by a lawyer. Without any intention of encroaching upon the legal profession, however, legal principles are here discussed in a language you and I can understand. My hope is that it will be of some interest to you and of some benefit in thinking upon the general subject of water in its elementary and fundamental phases.

THE NATURE OF WATER

Water is a product of precipitation, and hence a natural resource. It differs, however, from certain other natural resources in that it moves. It may be destroyed. Nature's way, with respect to water, involves constant change rather than a constancy of volume such as at times is ascribed to water under un-natural, and hence unenforcable, provisions of our legislation.

Water may not, except artificially and with uncertainty, be fixed, limited or defined as a constant property such as a piece of real estate. Some of our mistaken efforts to assign to water a constant property, which by its nature it does not possess, are as futile as to legislate that on certain days of each month it must rain.

[1] Presented before the Rocky Mountain Section meeting, February 14, 1930.

[2] Consulting Civil Engineer, Pueblo, Colo.

The fact that such legislation is attempted and that such rulings are, at times, made, is of itself a criticism of your occupation and mine. It is our business to take an active part in the building up of a body of laws which fit the nature of water and are naturally adapted to its proper control and utilization.

PUBLIC OWNERSHIP

Who owns the atmosphere and the rain clouds therein? When rain falls upon land and runs off in natural streams, who owns the water of such streams?

Inherently the title to water is vested in the public.

Public ownership of water arises out of a fundamental fact of necessity, namely, that water is essential to life.

We shall ignore the questions which develop out of the directness with which life is involved, giving rise to rights of relative value, such as domestic and municipal, irrigation and manufacturing rights, as being branches of the root idea under investigation.

Public control over water is necessary in the public interest.

Public interest, however, is not fixed and invariable the world over. It varies with the conditions of nature, one of whose gifts is water itself.

HUMID REGIONS

For the purposes of this study our globe may be divided into two parts, each approximately equal in the extent of land area.

Over one half, the rainfall is comparatively ample. These are called the humid regions. Here water is plentiful. Rainfall directly serves the needs of agriculture and creates a surplus which flows away in rivers to the oceans.

In humid regions there is little confusion over water as an agricultural agent. There is no need, essentially, for irrigation; and irrigation, if practical at all, assumes a form of crop insurance against periodic drouth, rather than the form of reclamation to which we, of the arid west, are accustomed.

In humid regions (water being plentiful) there is little confusion over domestic or municipal supplies. The uses to which the waters of natural streams are placed involve drainage or sanitation, navigation, power development and kindred purposes of a non-consumptive nature.

Such being the custom, a body of law develops, protecting the

public in the use of such water, protecting the owner of land along such streams in his rights therein, and limiting the rights of private utilization as opposed to the public interest. Such doctrines have come to be known as the "riparian rights doctrine," the abutting or adjoining lands being "riparian" to the stream.

Under that doctrine, the natural conditions of stream flow must remain substantially as nature creates and maintains them, which, of course, precludes any extensive development of works which might injuriously diminish the quantity or quality of water.

This riparian rights doctrine prevails over the eastern or humid half of the United States. It was inherited as part of the common law of England.

ARID REGIONS

The other half of our globe, and a part of the western half of our nation, are not so favored by nature in rainfall and stream flow. Instead, dry or arid conditions prevail, the rainfall being deficient for the agricultural needs of the land and the resulting stream flow being generally, in proportion to land areas, deficient in amount when utilized for irrigation purposes.

If these arid lands are to be reclaimed, if human occupation of them is to be sustained, then the deficiencies of natural precipitation must be compensated for by the appropriation of water from streams and its artificial application to land.

This custom, arising out of nature's deficiencies, is the custom of arid lands. It has been recognized throughout all history by a doctrine known as the "appropriation" doctrine, which under the surrounding conditions best serves public interest.

All our early civilizations, such as those of Rome, Egypt and the nations of biblical history, not only had such laws, but developed them to a remarkable degree. England adopted much of the Roman Law, but, under her humid climate, had no need for the doctrine of appropriation. Our Pilgrim forefathers left one humid climate and migrated to a another similar one.

Spain, on the other hand, is in part arid. The early Spanish settlements in what is now the United States (except those along the gulf Coast) were established under arid conditions. Had the Spanish Conquest of America been successfully completed, our early national doctrines, relating to water, would probably have been along the lines of appropriation rather than of riparian rights.

The sources of our national policies in this respect form an interesting study which, however, must be omitted in this discussion. Colorado has much to learn, however, from the Roman Law, which developed under centuries of experience, as compared with our state life to the present time of 54 years. Our courts might well consider the established precedents of nations located in arid regions, rather than simply construing the English Common Law which developed under entirely different natural conditions and customs.

EARLY FEDERAL RECOGNITION

However, our courts have not been lax in recognizing customs necessities, claims and rights in respect to the use of water. In fact, they have been generations ahead of our legislative bodies in that matter.

This is illustrated by the quotation from a very early case, Clough v. Wing (2 Ariz. 371), wherein the court comments,—

"The right of appropriation and use of water for irrigation has been recognized longer than history, and since earlier times than tradition. Evidences of it are to be found all over Arizona and New Mexico in the ancient canals of prehistoric people, who once composed a dense and highly civilized population."

In this connection it may be interesting, to note that the appropriation and use of water may be traced back in a connected manner, through records of the Spanish Conquest (when Santa Fe and Taos were the political and commercial centers of the country) to a time nearly a century before our Pilgrim forefathers landed on these shores.

But so far as Federal legislation was concerned the first white settlers upon our western public domain were simply trespassers. The first legislative enactment was in 1866. Long prior to that time our courts recognized the necessity for irrigation and the rights which grew up in connection therewith.

Thus in 1855 the case of Irwin V. Phillips (5 Cal. 140) was decided.

Extracts from this opinion indicate clearly the court's attitude. They said—

"Courts are bound to take notice of the political and social conditions of the country which they judicially rule.

"A system has been permitted to grow up by the voluntary occupation of the region, tacitly assented to by the Federal Government, and heartily encouraged by the expressed legislative policy of the State.

"If there are, as must be admitted, many things connected with the system, which are crude and undigested, and subject to fluctuation and dispute, there are still some which a universal sense of necessity and propriety have so firmly fixed as that they have come to be looked upon as having the force and effect of 'res adjudicata.'

"Among these, the most important are the rights of those who, by prior appropriation, have taken the waters from their natural beds, and by costly and artificial works have conducted them to supply necessities without which the most important interests would remain without development.

"So fully recognized have become those rights, that without any specific legislation conferring and confirming them, they are alluded to and spoken of in various acts of legislators in the same manner as if they were rights which had been vested by the most distinct expression of the will of the law makers."

ACT OF 1866

At the time of the first occupation and development of Colorado, dating about 1860, there was no legislative recognition of the right of appropriation, although as evidenced in the opinions cited, our courts fully recognized such rights.

In the eastern United States, a movement gained weight to have the Federal Government assert and assume ownership to all lands, mines, ditches and other resources and works developed upon and in connection with the public lands of the west.

This critical situation, for the west, was relieved by the passage of the Act of 1866 (now Sec. 2339 Revised Statutes of the United States) which states:

"Whenever by priority of possession, rights to the use of water for mining, agricultural, manufacturing, or other purposes have vested and accrued, and the same are recognized and acknowledged by local customs, laws and court decisions, the possessors and owners of such vested rights shall be maintained and protected in the same."

COLORADO'S CONSTITUTION

Ten years later, in 1876, Colorado became one of the States of the Union. It largely was created out of the Kansas Territory. Eastern Kansas was a humid region, and central Kansas nearly so. Western Kansas began to be settled about the time Colorado was admitted as a State. Its first efforts at irrigation were begun about 1880. The laws of Kansas concerned themselves little, if at all, with irrigation, the necessity for irrigation being eliminated by adequate rainfall over most of the State. Hence the Kansas law was largely that of our nation, being the English Common law doctrine of riparian rights.

In Colorado, on the other hand, the custom of irrigation had grown up with the occupation of the country. So firmly established had the system become that elaborate provisions for its recognition and regulation were written in to the State Constitution and were a part thereof when Colorado was admitted to the Union.

DIVISIONS OF THE ARID WEST

This co-called doctrine of appropriation and use has come to be known as the "Colorado Rule," which rule substantially prevails in several other typically arid states, such as Arizona, Idaho, Nevada, New Mexico, Utah and Wyoming.

The great arid west, involving nearly two-fifths of the area of Continental United States, includes other states where, in parts thereof, irrigation is practised. These other states constitute a border around the typically and wholly arid states, and in them various modifications of both the riparian rights doctrine and the appropriation doctrine prevail. Such states include California, Washington, Oregon, Montana, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma and Texas.

KANSAS V. COLORADO—CONDITIONS AT THE TIME

We come now to an interstate stream, the Arkansas River, having its origin in Colorado, and extending into and across portions of Kansas, Oklahoma, and Arkansas, then emptying into the lower Mississippi River and the Gulf of Mexico.

We arrive at the year 1901, some 25 years after Colorado became a State and about 40 years after the beginnings of irrigation development along the Arkansas River and its tributaries in Colorado. During that forty years irrigation development had grown and expanded until the stream flow was largely depleted.

In the latter half of this 40 year period some actual construction of ditches had taken place in Western Kansas. Projects involving immense areas had been promoted in both Colorado and Kansas, many of which never materialized.

As distinguished from the type of development in Colorado, largely the result of individual, coöperative, and mutual effort on the part of land owners and water users, the Kansas development was generally of the corporation type, much of the financing in fact coming from Europe.

These corporation investments, regardless of their location in a region of questionable, or at least erratic need for water, were improperly conceived and hence largely, as investments, failures.

The theory of the investment security was that land being plentiful and water scarce, the value would exist in the water. Water, of course, is without value unless it be beneficially used, and in connection with irrigation the value accrues, not to the water owner, but to the land owner upon whose land the water is used.

This condition, among others, resulted in careless operation and maintenance of ditches, on receiverships, and finally on more or less complete abandonment, perhaps not of the right but of the facilities. Eventually the ditches passed into the hands of a comparatively few land owners and water users, who fixed them up and, under cooperative or mutual effort, still continue to operate them.

CONTENTIONS KANSAS V. COLORADO

On May 20, 1901, the State of Kansas filed a bill against the State of Colorado and certain of her citizens, charging a wrongful diversion of the water of the Arkansas River, contending for the doctrine of riparian rights that the river should be allowed to flow as it formerly flowed without depletion thereof, and claiming that the diversions in Colorado not only deprived the Kansas riparian owners of land of the benefits of the flowing stream, but that all lands within the drainage basin were injured by a lowering of the ground water level and a diminution of the subterranean flow.

Colorado answered, contending for the doctrine of appropriation, claiming ownership of the waters of the streams of the State under its constitution, and alleging that the Arkansas River was in fact a broken river, the Colorado stream disappearing in Eastern Colorado and Western Kansas and the Kansas stream originating below that point of disappearance.

The United States intervened, contending that neither Colorado nor Kansas was correct in their contentions, that neither doctrine was applicable to the reclamation of the west, and claiming the Nation, rather than the State, must exercise primary control.

KANSAS V. COLORADO DECISION

After hearing testimony for several years, the Supreme Court, in May 13, 1907, rendered a decision. Contrary to popular belief, and differing from many comments to the effect that the case was

dismissed without prejudice, let us think for a moment of the opinion as it may be evidenced by certain extracts therefrom.

The issues raised were of far reaching importance. They naturally divide themselves into two groups. First, the issue raised by the Federal government was definitely settled, the court after commenting on the fact that navigation was not an issue, says:

"Each state has full jurisdiction over all the lands within its borders, including the beds of streams and other waters.

"It may determine for itself whether the common law rule in respect to riparian rights or that doctrine which obtains in the arid regions of the west of the appropriation of waters for purposes of irrigation shall control," and

"Congress cannot enforce either rule upon any State."

So that the case, instead of being dismissed without prejudice, apparently did settle definitely and finally some very important questions in the matter of title to water.

Turning now to the second issue between the two states, let us see what was determined. The general contention of Colorado that its doctrine of appropriation must apply in Colorado, regardless of what doctrine might prevail in Kansas was definitely sustained,—that "each state has full jurisdiction," and each may for itself determine its own doctrine.

Going further, as to the rights of Colorado under her particular doctrine to deplete the stream flow, the court found that Colorado's contention of a broken river could not be sustained, and the Arkansas was an interstate stream. It found further that:

(a) "the appropriation of waters of the Arkansas by Colorado, for the purposes of irrigation, has diminished the flow of water into the State of Kansas,"—

(b) "the result of such appropriation has been the reclamation of large areas in Colorado, transforming thousands of acres into fertile fields and rendering possible their occupation and cultivation when otherwise they would have continued barren and unoccupied."—

(c) "while the influence of such diminution has been of perceptible injury to portions of Kansas, particularly those closest to the Colorado line, (the opinion at another point mentioning the fact that in this district are located certain irrigating ditches which have been rendered largely useless) yet to the great body of the valley it has worked little if any detriment."

As a conclusion to such findings the bill of the State of Kansas was dismissed, which, as I read the opinion, means, that up to that time Colorado had not exceeded her rights in the stream.

At the same time the rights of Kansas in the common fund were admitted when the bill was dismissed without prejudice to the right of the plaintiff (the State of Kansas) to institute new proceedings,—it being obvious that "if depletion continues, there will come a time when Kansas may justly say there is no longer an equitable division of benefits," and may rightly call for relief.

This cardinal rule, not of an equal or any division of water, but of the equality of right, not to the means but to the end, is fundamental, and, generally, is followed in all interstate and many local matters.

Defining the rule somewhat more fully, the court said in substance, Kansas may again sue when her substantial interests (and no one can deny that agriculture is a substantial interest) are being injured, by reason of material increase in the depletion of flow of the Arkansas River by Colorado, to the extent of destroying "the equitable apportionment of benefits between the two states resulting from the flow of the river."

It seems so important to me, that I feel that every engineer dealing with water, and every water works superintendent should memorize such brief and general rules of equity. That rule, as I view it, is not only the one rule to be remembered in interstate conflicts, but eventually will assume more and more importance in local conflicts arising out of claims upon a public resource.

Twenty years of thinking upon this question, the reading of many other court rulings upon interstate and local conflicts, and the preparation of data for presentation before district and federal courts, gives a background for this conclusion, namely, when the adopted rule does not result in equity, then eventually shall come the termination of the rule.

NATURE OF OUR WATER RIGHTS

Turning for a moment to a consideration of our methods of apportioning, among rival claimants, the right to use a portion of this public resource, let us consider the nature of such right.

Under the natural conditions which force upon an arid region the doctrine of appropriation, there is at the same time demanded some rule whereby the water may be apportioned among the several claimants. The land area being in excess of the water supply, it may be assumed, from the nature of water, that all the supply will be appropriated or claimed, and that shortages will at times exist.

As a result there will be conflicts of interest, so that there is demanded some control, regulation, and restriction of the right to prevent discord, promote order, and attain maximum benefit from a limited public resource.

As to the control and regulation, that is properly assumed by the State. The restriction of the right, in the public interest, is provided for by the courts, and the working rule adopted was the priority rule, namely, that "he who is first in time is first in right."

This priority rule encouraged early development, and within limitations, serves the equities of the situation perhaps as well, if not better, than any rule which might have been adopted. As between rival claimants, each upon an equal footing, the priority rule is equitable, but as the physical and economic features of the institution of irrigation expand, we find that not all rival claimants are upon an equal footing, and that, as measured by the requirement of public benefit, the priority rule does not always serve equity.

We have mentioned that the priority right to the use of water is a limited right. By this is meant, that whether your decree is so worded on its face or not, there is written into it, nevertheless, a limitation to this general effect, "that beneficial use shall be the basis, the measure, and the limit of the right."

WHAT PUBLIC INTEREST DEMANDS

Such control as is exercised by the State, and such limitations as are provided by court decisions, may be expected to become more fully developed with time, with knowledge and with experience.

The old Romans developed the priority rule under centuries of experience to a point where the public interest was so paramount that the private right almost disappeared. Boiled down, they gave the water to that land most in need thereof where its application would result in the greatest good to the nation.

Certainly in the next generations we may expect to hear more and more of the matter of public interest. At the present time it is difficult to say, in any given set of circumstances, just what best serves public interest. Certainly I shall not attempt its definition.

But I do believe, as to the use of water in irrigation, and as to the public interest therein, we can indicate certain demands which are to be met in so far as present physical and economic factors permit, namely:—

1. That all the available supply be utilized. There being unlimited

areas of land to be served by limited water supplies, non-use becomes, essentially, waste. When the words used or utilized are employed, beneficial use is implied, as there can be no right sustained for non-beneficial use;

2. That conservation be practised. Conservation means the avoidance of waste, of unnecessary or excessive quantities, and, under present knowledge the fullest possible use and re-use of water, to increase its duty in relation to land; and

3. That the future be considered. The burden of irrigation is, in the light of constant climate, a permanent burden on a region. Future generations are to use our lands and our water supplies, and our present utilization should embrace that idea.

These three things, at least, seem to me to be some of the things demanded by public interest of the individual, or the group, or the state which asserts a claim upon stream flow as a supplementary agricultural supply of water.

SUBSEQUENT LITIGATION—THE 1910 CASE

Getting back to the Kansas-Colorado Controversy, about three years after the original Kansas v. Colorado decision, that is in 1910, another suit was filed.

This second suit was filed, not by the original plaintiff the State of Kansas, and not by water users in Kansas, but instead by a Wyoming corporation representing certain interests in some of the Kansas ditches. It was brought against a group of ditches in Colorado. Its object was to establish a date and priority amount and to have such date and amount recognized by some of the established enterprises in Colorado as though the matter had been adjudicated in the Colorado courts.

Manifestly a ditch in Colorado could not claim water from its upstream neighbor only to pass it along to a ditch in Kansas without the whole administrative and judicial set up of the State of Colorado becoming involved.

And similarly the matter of priority in Kansas became material. That matter having arisen in Kansas, with only meagre legislation for its guidance, it was settled among some of the then active claimants by stipulation under which priority rights were ignored.

Such a suit, if successfully prosecuted, would have resulted in this situation. The headgate of a ditch in Colorado would be closed down to supply water to a Kansas ditch of senior date. At the same

time, the water having reached Kansas would be diverted by ditches of junior date to the one in Colorado from which the water was taken away, and, if any of the water reached the plaintiff ditch of senior date, it would in part have been shared by others operating under the stipulation or rotation contract, even though those others were of junior date to the Colorado ditch.

Colorado contended that the States of Colorado and Kansas were both necessary parties to such litigation. But the Federal District Court ruled otherwise and assumed jurisdiction. The matter was carried along, until in 1916 a settlement was reached by contract. Under this contract the defendant ditches agreed to recognize the claims of the plantiff ditches, not as of the date of contruction, but as of 1910 when the suit was filed. Since the defendent decrees ranged from 1860 to 1906, all being senior to 1910, the settlement took nothing away from Colorado except a right of unlimited future development, and to that extent, some protection was offered to Kansas.

Other ditches in Kansas voluntarily became parties to this contract of settlement. A few small ditches near the Colorado line would not join, and one of the Garden City group of ditches stayed out.

This 1910 case was settled in 1916, the settlement being unsatisfactory in the sense that it did not bind all the ditches in each state nor the states themselves.

THE 1916 CASE

In the same year of 1916 in which the contract of settlement was concluded, this one "hold-out" ditch near Garden City, (which incidentally had requested and received Reclamation Act funds in the construction of a large pumping plant for furnishing a supplemental supply of ground water) took the same bill as had been previously filed and settled, and with a few appropriate changes began another action against the same Colorado ditches.

Somewhat later it filed another similar suit, this time naming a large number of water users including cities, scattered all over the Arkansas River and its tributaries. These two cases are, or were until recently, still pending.

Except in the original case, decided in 1907, Colorado has had no occasion to complete a defense of the other cases on the Arkansas River. The 1910 case was settled by contract. The 1916 case has been delayed for various reasons.

However, the position of the defendant Colorado ditches is clearly indicated by their answers. They consistently maintain that such private suits are in fact actions against the State of Colorado and all the water rights in the irrigation division; that they are attempts to secure for the State of Kansas a river flow which under its own original case it was denied; and that any rights which a ditch in Kansas may have it derives from the State of Kansas, who alone, under the original verdict, may renew its claim when and if the equitable apportionment of benefits becomes altered as between the two states.

THE ATTEMPTED COMPACT

About 1921 Colorado made provision for the study of interstate streams and for the settlement of controversies thereon by compact, appointing the Hon. Delph Carpenter as Compact Commissioner. Kansas was invited to carry out a similar program and in 1923 appointed a commission for similar purposes, which included Mr. Geo. S. Knapp, the State Irrigation Commissioner of Kansas.

These commissions met. They exchanged data. They labored over the problem, studying it from several angles and in many of its phases. Finally they produced a proposed compact.

In connection with negotiations of this nature, too much cannot be said of their value. But like many things so attempted there are limitations. In this case it is a lack of power to enforce upon the parties the will of the joint commission, and the political angle which develops in securing ratification.

However, the proposed compact is valuable as a guide to the study here involved. It may be discussed since it has been printed and publicly distributed by the Kansas State Board of Agriculture, being in the form of a report by the Irrigation Commissioner to the Board. The compact provided, among other things:

(1) For the adjustment of periodic shortages in water for all the Kansas ditches which might have any claim to water, including (a) the one Kansas Ditch then suing, (b) the ditches formerly settled with by contract, and (c) all others.

(2) This control and regulation to be accomplished by the construction and operation of reservoirs, such reservoirs to be constructed to specified capacities, and located, if so desired, in Colorado. In connection with such reservoirs in Colorado, while they were to be built by Kansas, still Colorado would furnish the necessary rights-of-way.

Commenting upon the proposed compact, the Kansas Irrigation Commissioner explains that the object of the reservoirs was to store existing surplus supplies for release when needed in Kansas to supplement amounts now received by the Kansas ditches from direct flow; he explaining that

(a) the natural summer flow of the river has been over-appropriated for years, under which property rights have become vested;

(b) in total and on the average the river flow into Kansas is sufficient to meet the demands of all the Kansas ditches; but that storage is required to prevent periodic seasonal shortages in natural flow; and finally

(c) lack of interest, and finally distrust in the project on the part of the plaintiff Kansas ditch, caused the abandonment of negotiations.

Whereupon that ditch became active again is the prosecution of its pending cases, demanding for itself a date and amount which it believed would create a sufficient supply for its needs without the expense of pumping or of storage.

Boiled down, this pending controversy has been kept alive all these years since 1907 not by the State of Kansas, and not by all the irrigation interests in Kansas, but by a few ditches. One ditch attempts to assert a technical claim as against Colorado, while at the same time it abandons the same claim as against its neighbors in Kansas, and ignores many of the considerations of equity such as must pertain to all claimants, to the end that the priority rule, if enforced would result in equity.

Having failed to overthrow the entire institution of irrigation by challenging the whole doctrine of appropriation, it now reverses its position and claims a priority under the appropriation doctrine. It claims that priority, not under Kansas control and regulation, and not as against its neighbors in Kansas, but only as against Colorado priority rights.

RECENT COLORADO V. KANSAS

As a result of this continuing policy and after a careful and complete study of all the physical and economic facts involved, which were compiled into a series of reports for the attorneys, and they having digested the data in the light of court rulings, a decision was reached which for the first time, so far as I am aware, in all its long history of interstate litigation, placed Colorado on the offensive.

Colorado, some two years ago, filed a bill directly in the Supreme

Court of the United States, asking that court to enjoin the prosecution of these pending cases. That court has taken jurisdiction. Such an action was a demand on the State of Kansas that it assume jurisdiction over its waters and over its irrigation enterprises, and an invitation that it renew its claim, if it had any, against the State of Colorado.

In answer, Kansas filed a bill against Colorado, alleging among other things, injury by reason of the construction of new projects in Colorado, i.e. since 1907 or 1910; alleging that the acreage irrigated in Colorado has increased; alleging that diversions of water have increased, and that river flow has been further depleted. Such allegations remain to be proven at a proper time.

Whereupon Colorado will present such record evidence as may appear necessary to describe properly the legal, physical, and economic situation as to the use and disposal of water, in connection with all points in controversy.

THE VALUE OF RECORDS

This brings the situation up to date, as it may at this time be explained. What lessons are to be learned from this general historical sketch? One lesson, which should be emphasized, is the value of records.

After all, the best proof of title to water is a record of its use, its benefits, and its service. Today we are all properly impressed with what might be termed technical or paper title;—tomorrow we will hear more of fundamentals involving economic rights.

Upon a record which we believe, within reasonable limitations, to be full, complete and accurate, we are submitting the whole case, involving rather immense values and far reaching effects. To illustrate, the Arkansas Valley in Colorado involves 14 counties in which live about 275,000 people. In five of those counties, wherein irrigation is the one chief industry, we have created, largely out of a wilderness or a desert, an empire of 125,000 people, who pay taxes on $160,000,000 worth of property, and in which the agricultural values alone are $64,000,000.

Fortunately, as we think, we look across our State line into Kansas, and there see an equally prosperous empire, the picture of which becomes an essential part of the completed story.

SUMMARY

In conclusion, let us try to summarize into a few sentences the valuable ideas to be gained from such an historical sketch. What lessons are there for you and me who presume to know something of one of nature's resources, namely, water?

1. We should understand the subject with which we are dealing. Water is one of nature's products. Our mission in life is to direct that product to the beneficial uses of mankind. We know that nature's laws are not easily understood, but are complex and often apparently contradictory. How then can we expect to improve our position in this mission of the direction of water to beneficial uses unless we think fundamentally and clearly, unless we think coöperatively with lawyers, legislators, and courts, to attain a proper starting point for all our efforts?

2. Not only must we deal with the natural properties of water, but we must, for our training and experience to become of real value to humanity, think upon the legal and the economic phases of the subject. By that I mean that the technical side is but one, and often a minor phase of the whole. We must think further of the nature of ownership and of the nature of the right granted for the use of water. We must comprehend the inherent limitations of that right, and must recognize the responsibilities attached to ownership and the right of use. Now I do not mean to try to become lawyers or economists, but I do know that one of the reasons they do not understand our language is because we do not understand theirs.

3. It is our duty to compile accurate and complete records, and often to interpret those records in condensed terms. A third message involves the manner of keeping records. What we are after is the truth. Facts, properly interpreted, point to the truth. Records are the best evidence of facts. In compiling records, search for the truth rather than the reverse performance, too often practised, of first forming a theory and then seeking data in its support. Having collected a lot of data and being called upon to explain its meaning, leave out the color,—the best picture after all is black and white (so many people are color blind).

4. And finally, have faith in your legislative, administrative and judicial agencies. If they fail to pass the laws we think are needed, it probably is our fault. If our courts render verdicts which fail to solve the situation, it probably is our fault that we sat back, knowing what we know, and letting the other fellow find out for himself.

True, our first duty is among ourselves,—to learn more of our subject by this type of interchange of ideas. But having learned, we have assumed at once a responsibility of making that knowledge applicable to the benefit of mankind. Any other knowledge, not so beneficially applied, is like "a paper-title" to water,—when that use is not beneficial, the right simply does not exist.

NATURAL AND ARTIFICIAL PURIFICATION OF THE SANGAMON RIVER[1]

By Charles H. Spaulding[2]

The purpose of this paper is to report in a brief summary the results of studies of the B. coli content of Sangamon River at Springfield, Illinois, before and after the inauguration of complete sewage treatment at Decatur, and to compare the protection afforded by stream purification alone with the added effect of sewage treatment and with the efficiency of water purification at Springfield.

NATURAL PURIFICATION OF SANGAMON RIVER

The Sangamon River rises in Illinois, drains 5,670 square miles of rolling prairie, and empties into the Illinois River. For the greater part of its total length of 180 miles, it has a fall of less than 2 feet to the mile (1). The bed is mostly through sand and gravel, but the sand and gravel are usually well concealed with silt.

The Springfield Water Works is located 39 miles above the mouth of the river, and Decatur is 55 miles above Springfield. The river below Decatur is heavily polluted by Decatur sewage, and serious nuisance conditions existed prior to 1928. These conditions have been corrected by the disposal works, but the presence of contamination is still plainly evident in the concentration of B. coli in the stream. Numerous surveys have been made showing the continuity of pollution and indicating the absence of important contributions from other sources unless they occur at high stages when crucial sampling points are inaccessible. The possibility exists of a contribution from sewered population on two other tributaries. The fact that current velocities in these tributaries are much lower (one-half to one-fifth in several observations), probably accounts for the relatively small concentrations of B. coli found near the mouths of these streams.

[1] Presented before the Water Purification Division Session, Toronto Convention, June 26, 1929.

[2] Superintendent of Water Purification, Department of Water, Light and Power, Springfield, Ill.

The surveys of the main stream show the vigorous progress of self-purification at normal river stages and below (2 feet on the gage is called normal). But they also show that these processes can be completely upset by a rise of a foot or less in the river. I have come to believe that occasional surveys are treacherous guides to a quantitative estimate of stream pollution.

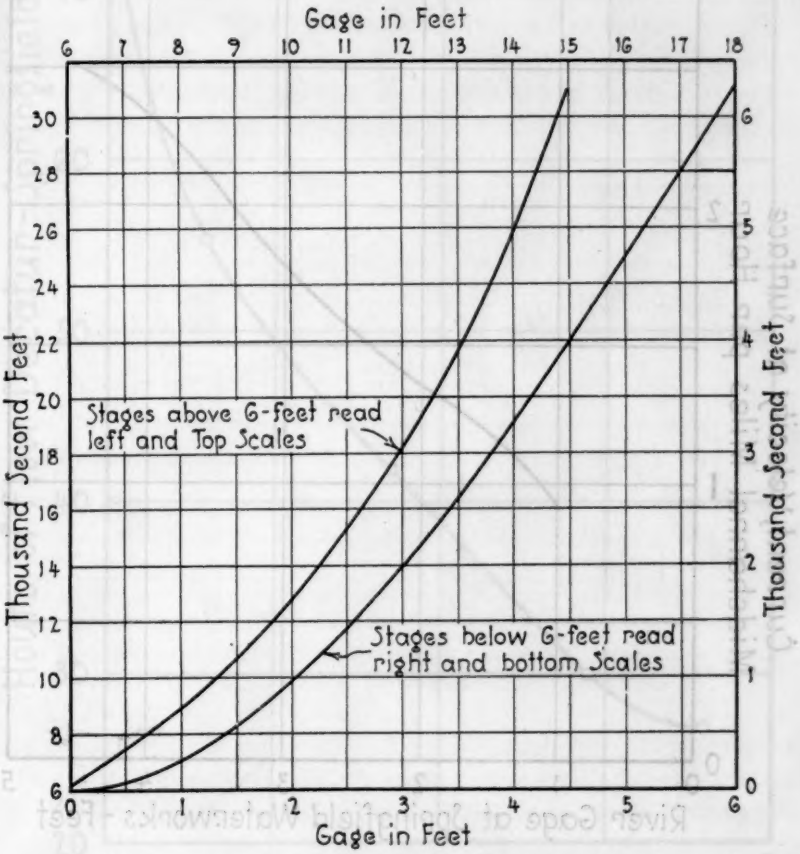
Gage in Feet
6 7 8 9 10 11 12 13 14 15 16 17 18
30 28 26 24 22 20 18 16 14 12 10 8 6
Thousand Second Feet
Stages above 6-feet read left and Top Scales
Stages below 6-feet read right and bottom Scales
0 1 2 3 4 5 6
Gage in Feet
6 5 4 3 2 1 0
Thousand Second Feet

FIG. 1. DISCHARGE RATING CURVE, SPRINGFIELD WATERWORKS GAGE

It is not within the scope of this paper to discuss the mechanism of self-purification, but it has seemed advisable to indicate the method by which I arrive at the value placed on the natural processes, and this necessitates some elaboration.

The rise and fall of bacterial content is unmistakably reflected in

the dilution, current velocity, time of flow from Decatur, temperature and turbidity. A group of charts showing these relations has been prepared from the daily records covering fifteen months from September 23, 1926, to December 31, 1927.

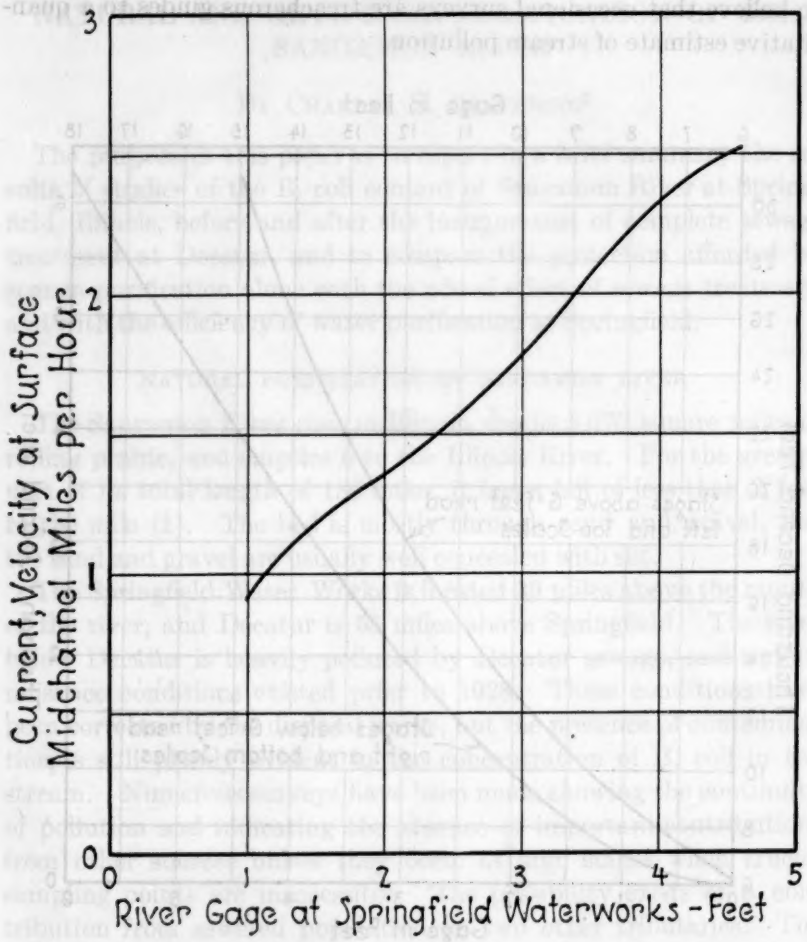

FIG. 2. SANGAMON RIVER, DECATUR—SPRINGFIELD. RELATION OF CURRENT VELOCITIES TO RIVER STAGE

Figure 1 shows the discharge rating cuves for Springfield Water Works gage. During the period under discussion the discharge has ranged from 50 to 33,000 second feet. By the use of the discharge curves we are able to convert bacteria per cubic centimeter into

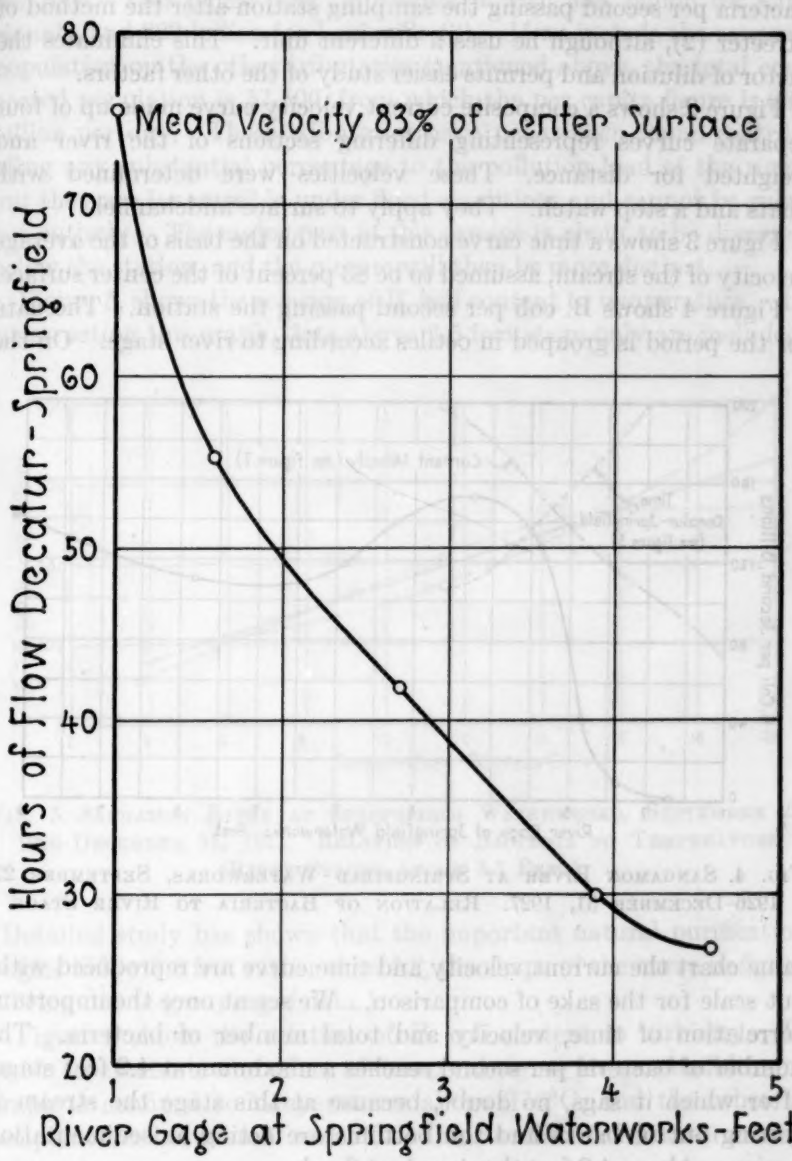

FIG. 3. SANGAMON RIVER, DECATUR—SPRINGFIELD. RELATION OF TIME OF FLOW TO GAGE READINGS AT SPRINGFIELD WATERWORKS

bacteria per second passing the sampling station after the method of Streeter (2), although he uses a different unit. This eliminates the factor of dilution and permits easier study of the other factors.

Figure 2 shows a composite current velocity curve made up of four separate curves representing differing sections of the river and weighted for distance. These velocities were determined with floats and a stop watch. They apply to surface midchannel.

Figure 3 shows a time curve constructed on the basis of the average velocity of the stream, assumed to be 83 percent of the center surface.

Figure 4 shows B. coli per second passing the station. The data for the period is grouped in octiles according to river stage. On the

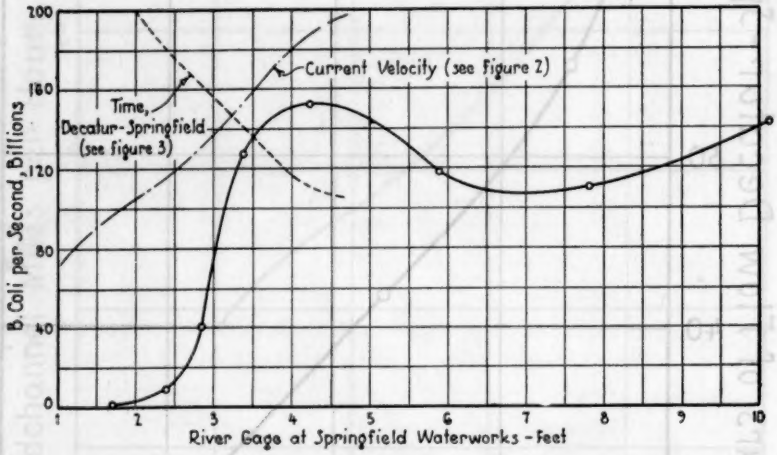

FIG. 4. SANGAMON RIVER AT SPRINGFIELD WATERWORKS, SEPTEMBER 22, 1926–DECEMBER 31, 1927. RELATION OF BACTERIA TO RIVER STAGE

same chart the current velocity and time curve are reproduced without scale for the sake of comparison. We see at once the important correlation of time, velocity and total number of bacteria. The number of bacteria per second reaches a maximum at 4.2 feet stage, after which it sags, no doubt, because at this stage the stream is getting out of banks and the bottoms are acting as sedimentation basins. Above 4.2 feet the river is at flood.

We are fairly convinced also that at this stage we are getting all the bacteria there are. The contributing population of Decatur is stated by Dr. Hatfield to be 40,000. The number of B. coli per second is 153 billion, which is equivalent to 330 billion per capita

per day. This figure may be compared with 358 billion for Cincinnati, and 222 billion for Louisville (3). If we include the sewered population on the other tributaries mentioned above, the total connected population is 57,500, from which the per capita figure is 230 billion per day. These tributaries have never been found contributing any substantial percentage to the pollution load of the river, but they are inaccessible under flood conditions and cannot be ruled out entirely. The major part of this sewage is about to be diverted below the station, and the picture will then be more distinct.

Figure 5, shows the relation of B. coli content to temperature. In constructing this graph, data above 3.5 feet stage only are included.

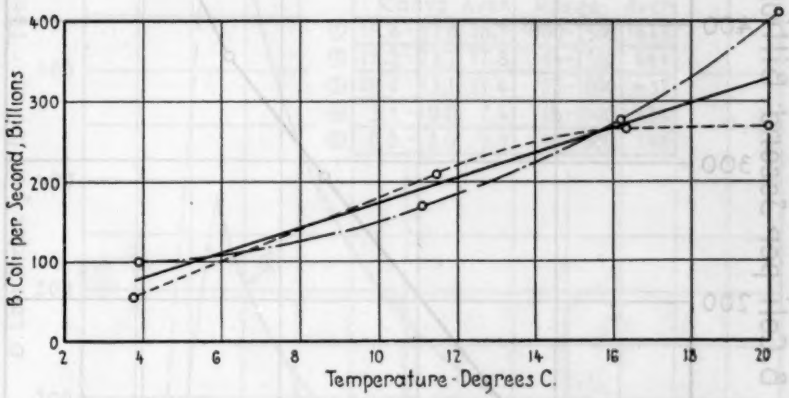

FIG. 5. SANGAMON RIVER AT SPRINGFIELD WATERWORKS, SEPTEMBER 22, 1926–DECEMBER 31, 1927. RELATION OF BACTERIA TO TEMPERATURE (RIVER STAGES ABOVE 3.5 FEET)

(Detailed study has shown that the important natural purification begins below 3.5 feet rather than 4.2, the shape of the curve in figure 4 being due to grouping of data.)

Figure 6 shows the relation of B. coli content to turbidity. In order to eliminate the effect of temperature as far as possible, one graph is confined to temperatures above 15°C. and the other to temperatures between 0° and 5°C. Intermediate temperatures were scarce.

Figure 7 shows the results of these studies translated into usual terms of B. coli index per 100 cc. It may be explained that the curves to the left of 3.5 feet stage are the effect of natural purification. To right of 3.5 feet they are dilution curves.

The value of natural purification is apparent. It is not so much the difference between the peaks and valleys of figure 7, but rather the comparison between the peaks shown and those which would

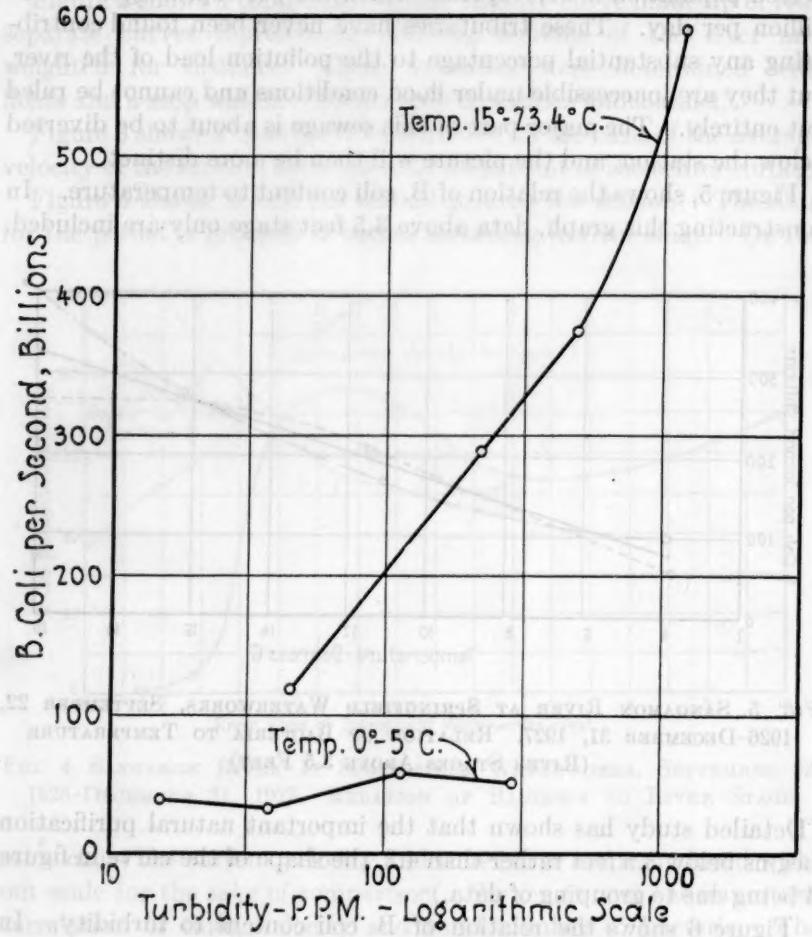

FIG. 6. SANGAMON RIVER AT SPRINGFIELD WATERWORKS, SEPTEMBER 22, 1926–DECEMBER 31, 1927. RELATION OF BACTERIA TO TURBIDITY (RIVER STAGES ABOVE 3.5 FEET)

be obtained if these dilution curves were continued to the lowest stage of the river without natural purification.

For example, we have found 153 billion B. coli per second as the yearly average at 4.23 feet stage. The discharge at this stage is

3,630 second feet, and the index is 148,500 per 100 cc. We have had as low as 0.4 foot gage within the past year with a discharge of only 50 second feet, and at this stage our index would therefore be

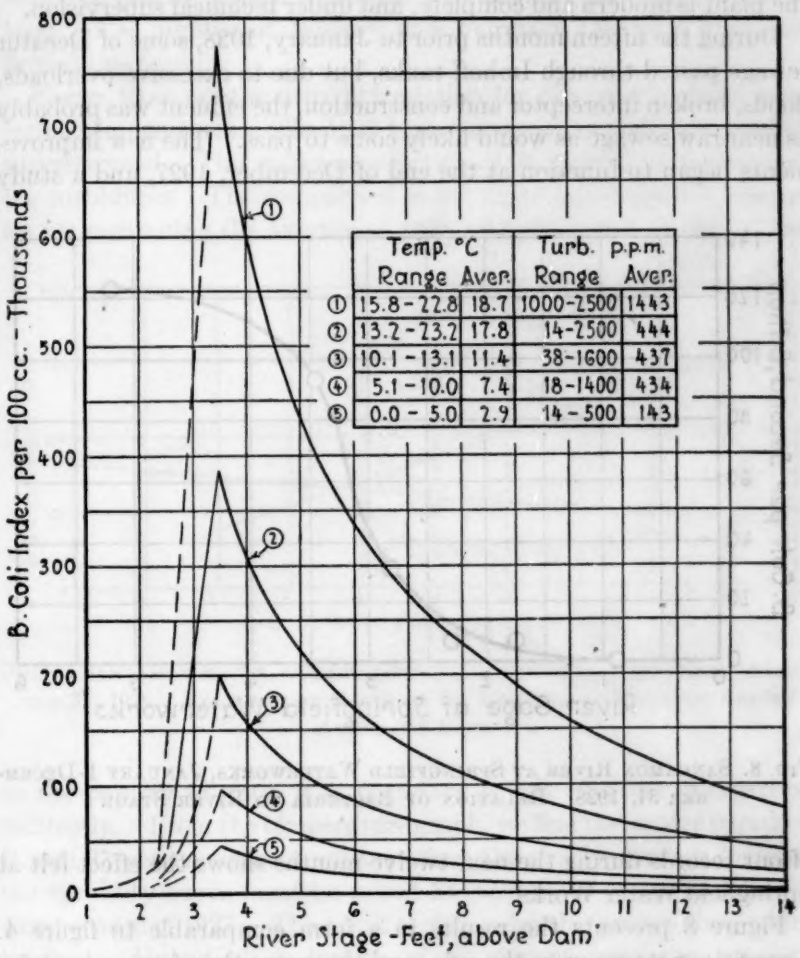

FIG. 7. SANGAMON RIVER AT SPRINGFIELD WATERWORKS. RELATION OF RIVER STAGE TO B. COLI INDEX AT VARIOUS TEMPERATURES AND TURBIDITIES

10,800,000. Hence, the potential efficiency of the process is 98.4 percent, and it can be relied upon. In fact, we do rely completely on this factor because a load of 10,800,000 is far beyond our limit.

THE VALUE OF SEWAGE TREATMENT

The problems of sewage disposal at Decatur and the present plant have been described in detail by Greeley and Hatfield (4). Briefly, the plant is modern and complete, and under technical supervision.

During the fifteen months prior to January, 1928, some of Decatur sewage passed through Imhoff tanks, but due to excessive overloads, floods, broken interceptor and construction, the effluent was probably as near raw sewage as would likely come to pass. The new improvements began to function at the end of December, 1927, and a study

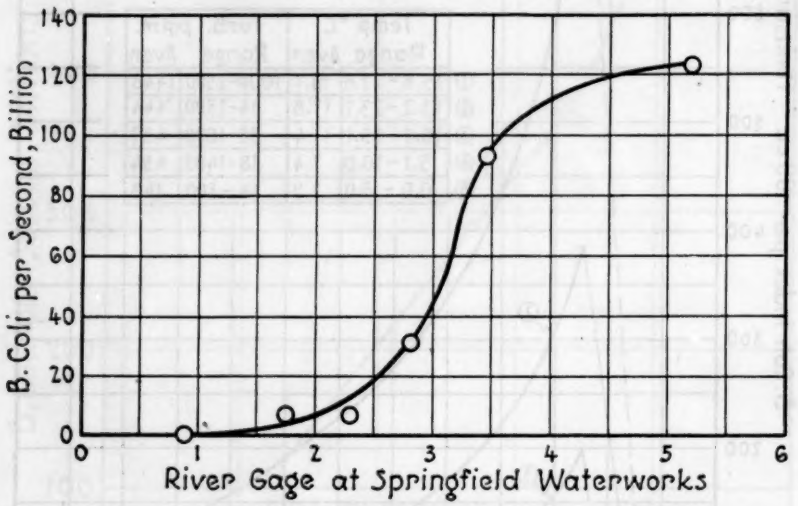

FIG. 8. SANGAMON RIVER AT SPRINGFIELD WATERWORKS, JANUARY 1–DECEMBER 31, 1928. RELATION OF BACTERIA TO RIVER STAGE

of our records during the next twelve months shows the effect felt at Springfield Water Works.

Figure 8 presents the results in a form comparable to figure 4. Lower river stages were the rule, and the curve therefore ends at 5.2 gage reading. The average at this stage, which includes sixty-one samples or one-sixth of the year, is 123 billion per second. This is not a great reduction from the previous average of 153 billion per second. However, the meteorology of the season is to be considered. This is reflected in the temperature and turbidity graphs.

Figure 9 shows the relation of temperature with the 1927 record reproduced. The condition of the river during the summer is seen

to be much improved, while winter conditions are not as good as in the preceding year. The phenomenon of higher concentrations in warm months is normal for raw sewage pollution (5), but the reversal of this by sewage treatment was unsuspected by the writer at least. The months of January and February this year have confirmed this trend.

Figure 10 shows the turbidity relation for the year without separating temperatures. The 1927 high temperature turbidity graph is superimposed. This shows a reduction of 65 percent at corresponding turbidities. The comparison is not quite fair, however, because we are comparing the average of 1928 with the worst of 1927. Due

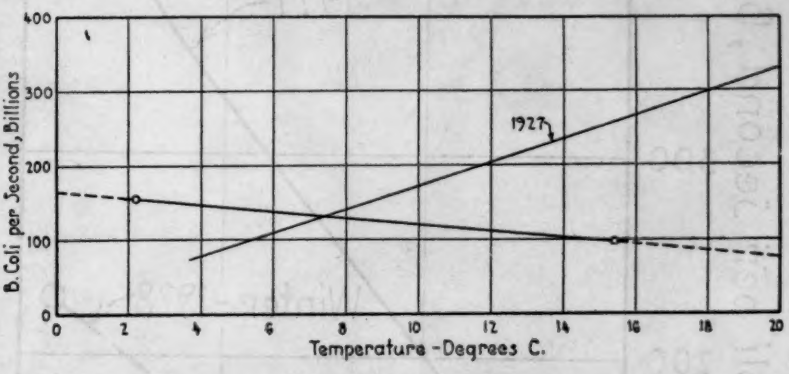

FIG. 9. SANGAMON RIVER AT SPRINGFIELD WATERWORKS, JANUARY 1–DECEMBER 31, 1928. RELATION OF BACTERIA TO TEMPERATURE (RIVER STAGES ABOVE 3.4 FEET)

to the paucity of data, it is necessary to get at a fair comparison indirectly. From the temperature graph, we find the winter parade of B. coli 33 percent more numerous than the yearly average. Hence the turbidity curve must be raised 33 percent to compare with the worst season of 1927. The result is shown by the broken line, which implies a dependable reduction of 56 percent from the previous critical conditions.

The possible contribution from 17,500 other population has already been mentioned. To introduce this complication would not improve the showing for treatment greatly, if at all, because the raw sewage is at its best in winter, and the data indicate that a winter-summer comparison would make a better case for raw sewage than for treated.

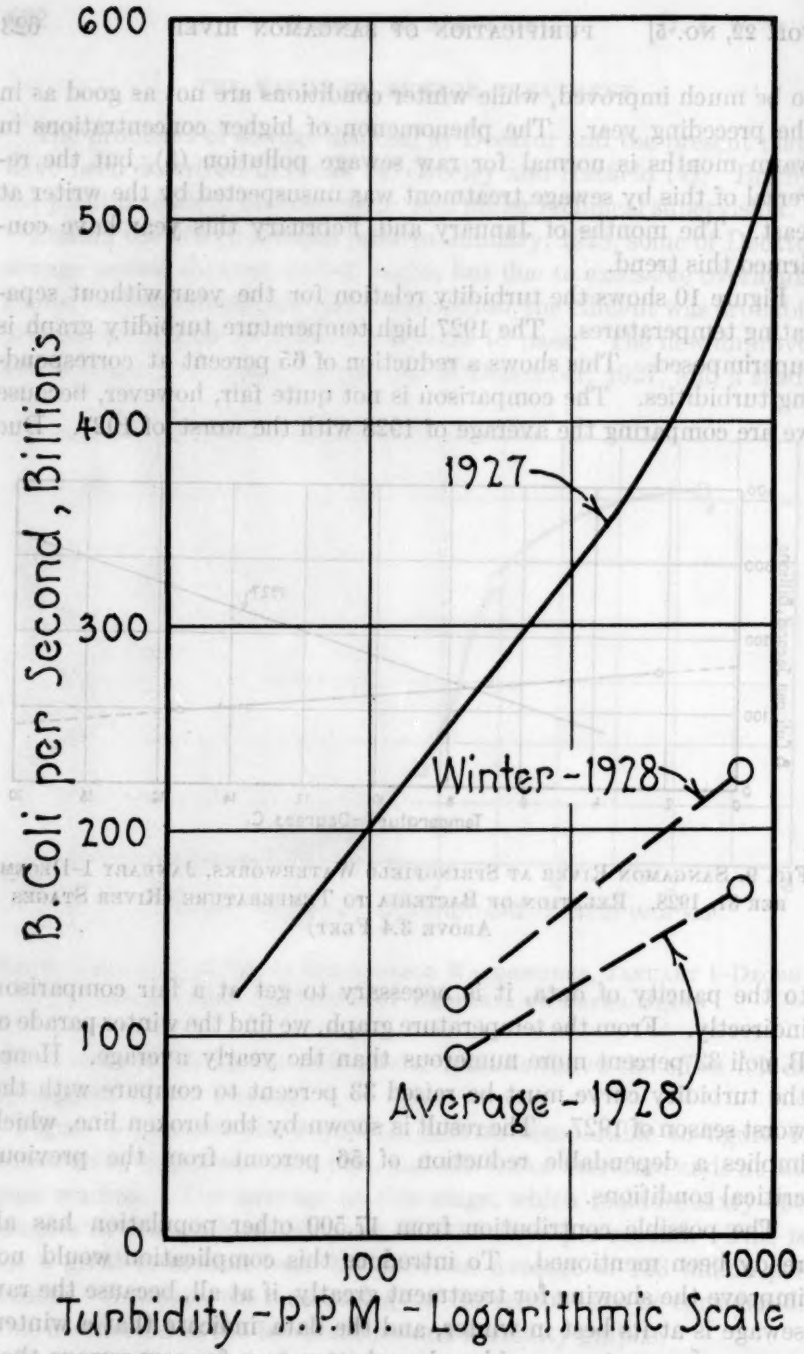

FIG. 10. SANGAMON RIVER AT SPRINGFIELD WATERWORKS, JANUARY 1–DECEMBER 31, 1928. RELATION OF BACTERIA TO TURBIDITY (RIVER STAGES ABOVE 3.4 FEET)

An unfortunate phase of this situation from the standpoint of water purification is that the sterilizing efficiencies of lime and chlorine are lowest at low temperatures. Hence, when all is said, we are not greatly benefited by the bacteriology of sewage treatment thus far.

WATER PURIFICATION AT SPRINGFIELD

Data on the operation of the Springfield water purification plant have been published by the writer (6). During the past two years ending February 28, 1929, the treatment has been as follows: lime softening to slight causticity, auxiliary alum coagulation, filtration and chlorination. During the past year, preammoniation and prechlorination have been practiced, with results already described (7). During the past four months, high causticity (40–50 p.p.m.) has been adopted, followed by partial carbonation of the applied water and final carbonation of the filtered water. This shows an increased efficiency, but does not eliminate the necessity of liberal use of chlorine.

The record for the two years ending February, 1929, shows a reduction of B. coli index from 20,464 per 100 cc. in the raw water to 0.30 per 100 cc. in the plant effluent. The average efficiency would therefore be 99.9985 percent. However, in evaluating the other stages of purification, I considered only maximum or critical loads, and this should be done with the final process for the sake of consistency. The B. coli index of the raw water was 100,000 per 100 cc. on 37 days of 1928. The filtered water showed 0.29 per 100 cc. Hence the percent reduction was 99.9997.

Lest some may note a discrepancy between the maximum river and maximum raw water concentrations, it should be stated that the river water entering the plant is diluted by an auxiliary ground water supply.

COMPARISON OF PROTECTION BY THREE AGENCIES

The three agencies at work in the regeneration of Sangamon River water are compared as follows: The natural process leaves a residual of 1.7 percent, sewage treatment leaves 44 percent; and water purification leaves 0.0003 percent of the load of B. coli which would otherwise be delivered at times to the consumers of this water. In other words, artificial purification with lime, chlorine, coagulation and filtration, has 5700 times the value of natural purification, and 150,000 times the value of sewage treatment in this particular case.

The writer hastens to disclaim any attempt to discredit sewage treatment in general or particular. The task of sewage disposal is important, aside from the bacteriological phase presented in this paper. A conclusion which he would most emphasize is that conservation of natural purification in our streams is a highly important element in any conservation policy. Even though artificial water purification has gone the greatest distance in the protection of the consumers of Sangamon River water, it still leaves a gap which at present is filled by natural purification and ground water dilution.

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(2, 3, 5) Frost and Streeter: Public Health Bulletin No. 143, p. 244 and 252.
(4) Greeley and Hatfield: Proceedings A. S. C E., October, 1928.
(6) Spaulding, C. H.: J. A. W. W. A., vol. 18, p 60, 1927.
(7) Spaulding, C. H.: J. A. W. W. A., vol. 21, p. 1085, 1929.

DISCUSSION

H. F. Ferguson:[3] The City of Springfield with which Mr. Spaulding is connected, and the Springfield Sanitary District, with which I am connected, jointly obtained an injunction about a year ago against a drainage district, which was proposing to shorten the travel between Decatur and Springfield from about 55 to 35 miles, and at the same time to increase the velocity between Decatur and Springfield.

The injunction was obtained on the basis of affidavits, and the Court is now hearing facts to decide whether the injunction shall be made permanent or dissolved.

The application turns upon this, that Springfield asks that it be determined that the present load upon the Springfield waterworks is too high for continuous safety, and further that the channelization of the Sangamon River would decrease the time between Decatur and Springfield, and would increase the hazard upon the Springfield water supply.

Mr. Spaulding referred to the treatment at Decatur as capable of producing an oxidized effluent. I think, however, that all units have not been in service continuously. The filters have been out of commission at different times, because the effluent is below high water stages.

[3] Chief Engineer, State Department of Health, Springfield, Ill.

The effect of the sewage treatment has been measured by the B.O.D. There has been reduction ranging from 90 to 30 percent. When all units are in service the plant can effect a reduction of 90 percent, but I think only 30 per cent has been obtained as yet over an extended period.

Decatur has a combined system of sewers, and during rainfall the greater bulk of the raw sewage from Decatur goes into the Sangamon River without any purification. That includes industrial waste at Decatur, which is about twice as much, measured in B.O.D., as the domestic sewage from the city.

Mr. Spaulding's measure shows a velocity up to about two and one-half miles an hour. In the court records of the drainage district they content that the channelization of the river would produce a velocity of 6 to 8 miles an hour. After the drainage district started activities they filed a claim against the City of Decatur for $100,000 as alleged benefits that the Decatur Sanitary District had obtained from correcting the flood conditions of the river. In order to make their case as good as they could they claimed channelization would increase the velocity from 6 to 8 miles an hour. Now I believe the drainage district wish they had not stated the velocity would be so great. Since Springfield has filed its case against Decatur the drainage district has filed a cross-bill against Decatur.

Dr. Bartow, I think, has done some work for Decatur, and it is a good thing he has good long legs as he has quite a problem to straddle at Decatur. However, Springfield is interested and Decatur is equally interested in protecting Springfield's water supply. It is a case of friendly litigation with the exception of the drainage district which has a considerable financial interest involved.

In closing my discussion I believe this problem at Decatur emphasizes again the need of further study of the amounts of treatment which should be given in sewage and water treatment plants, in relation to the economic factors. Here is Sangamon River which it is proposed to channelize, and improve the farm lands; what are the values of the farm lands; what will be their increased value? What is the cost of channelization; what is the cost of maintenance? What is the cost of treatment at Decatur including chlorinating the sewage? What is the value of river conservation as a whole?

Edward Bartow:[4] As I have been mentioned in connection with this work at Decatur and have had some relation with the Sanitary District at Decatur and also with the factory located there, I may say both the Sanitary District and the factory have been very much interested in helping Springfield to get a good water supply.

A few years ago before the sewage plant was started the population load measured in B. O. D. was approximately 300,000, and at that time the Sangamon below Decatur was in very bad condition. The citizens of Decatur and those living below formed Associations and were going to forbid the Sanitary District of Decatur from emptying its sewage and the factory from putting its waste into the river. A sewage purification plant was built with a capacity of 150,000 population load. The factory took measures to retain its waste in the factory and reduced its load from 240,000 to the present approximately 50,000, or under normal conditions the sewage purification plant would have handled from 90,000 to 100,000 population load.

Both Mr. Spaulding and Mr. Ferguson have mentioned that in high water periods part of the sewage of the city goes into the river untreated. That has happened several times, but I think not to such an extent as Mr. Ferguson mentioned. In times of high water there will be two or three periods each month when it is the practice to by-pass some of the untreated waste, but as a rule part of the waste is partially treated. A condiderable portion is treated, and there have been times in high water when the sprinkling filters were out of commission. There has been a lot of high water and the filters have been out of commission a great deal.

There is 50 percent purification and with sprinkling filters operating and the population load, as measured in B. O. D., is down to from ten to twenty thousand that means that the dilution with water gives a result obtained in low water which Mr. Spaulding has indicated as satisfactory. It seems very interesting that he has been able to locate at 3½ feet the worst stage above that dilution, and as Mr. Spaulding said sedimentation serves to purify the water.

Just what attitude Decatur and Decatur's Sanitary District will take in this lawsuit one cannot tell. The situation is interesting and there will be something for the Court to decide at a later date.

[4] Head, Department of Chemistry, University of Iowa, Iowa City, Ia.

CARL C. GIBBS:[5] At Great Lakes, Illinois, we have an increased population, and they had no way of taking care of the sewage, and the sewage went into the lake. We found at times there were epidemics of dysentery, and we tried to trace it to food and ice cream, and finally traced it to water. Investigators decided that the highly diluted water, even if it did not show the presence of B. coli, would cause an irritation of the intestines and cause dysentery.

H. F. FERGUSON:[3] The question might occur in the minds of some of you why Springfield started the action now Decatur has a purification plant, and why was the action not started before when the river was in a worse condition. Formerly Springfield obtained its water supply from wells and only within the last few years has water been supplied from the river, the river was worse several years ago than now, but it was not the main source of water supply.

Dr. Bartow, when speaking of the raw sewage that is by-passed, I believe, has considered only the by-pass at the sewage treatment works. There are four main by-passes before the sewage reaches the plant and by means of these large volumes of raw sewage reach Sangamon River.

[5] Superintendent, Glencoe Water Plant, Lake Forest, Ill.

ELEMENTS OF EFFICIENCY IN WATER WORKS OPERATION[1]

By Adolph Kanneberg[2]

One of our nationally known efficiency experts said that there are thirteen fundamental principles of efficiency, namely:

1. Standards
2. Records
3. Plans and Schedules
4. Dispatching
5. Standardized conditions
6. Standardized operations
7. Written standard practice, instructions
8. Ideals
9. Common sense
10. Competent counsel
11. Discipline
12. The fair deal
13. Efficiency reward

The first seven principles are of a practical nature, the others ethical. Let us briefly examine the practical principles.

We believe we do not need to discuss the need of standards without which measurements and comparisons could not be made. The necessity for them will be apparent to all water-works operators.

As to records, life as it is today would be impossible without them; they are an incentive to improvement. They annihilate time and space, bring back the past, and give us dependable glimpses into the future. They measure progress and show its direction, warning us of wrong methods, unwise procedure and inefficient operations. They check extremes, show the way to short cuts, and locate waste.

The records in themselves may be of little value. It is the data they supply and the use to which they are put that establishes their value.

From your records, plans and schedules can be evolved and with

[1] Presented before the Wisconsin Section meeting, September 8, 1929.

[2] Member, Railroad Commission, Madison, Wis.

the proper dispatching the efficiency of the plant increased. The principle of dispatching is a simple one, its gist being that when the time comes to do a thing everything should be on hand and prepared, so it may be promptly accomplished.

Standardized conditions are necessary as a basis for comparing and directing operations. Standard operations under standard conditions should produce standard results.

Standardized operations are orderly and replace guesswork by accurate knowledge, while written standard practice instructions give definiteness and direction. As will be pointed out later, a complete set of rules and regulations, governing all operations of the water utility and its relations with the public, will set out in definite, concrete and practical form a guide to follow to secure efficient operation besides serving as a ratchet to the utilities, progress by tending to prevent its slipping back.

The six ethical principles enumerated will not be discussed here in detail, but in the following pages some applications of the various principles of efficiency to the problems of water works operation will be noted.

EFFICIENT MANAGEMENT

The Board of Water Commissioners, whose duties are set forth in section 66.06 of the statutes, is an operating body, a body of directors so to say, while the city is the owner in fee of the property subject to such encumbrances as it may have incurred in connection with the acquisition of the property. The city in its ownership and operation of a public utility is acting in its corporate and not in its public or governmental capacity.

The authority of the Board of Water Commissioners is limited to operating and maintaining the plant. It can only contract to purchase, construct and install extensions, etc., to the plant when such extensions have been ordered and funds provided therefor by the city council. The city council cannot make appropriations out of the income derived from the operation of the plant for extensions or additions unless the other things specifically mentioned in Sec. 66.06, subsection 11c Stat., have been provided for.

The 1923 legislature amended Sec. 66.06, subsection 10g of the statutes by providing that a municipally-owned utility may be operated if the city council so decides by the Board of Public Works instead of a Water Commission. The Railroad Commission has

always contended that it is mandatory that a municipal public utility be operated by one or the other of the above mentioned boards.

From an examination of the records of the various utilities we find that the large municipally-owned utilities are mostly in charge of the properly constituted Boards. Most of the smaller ones, however, are operated by council committees. The efficiencies of the various operating boards and committees of different utilities vary widely.

A water utility should be handled as a business proposition, separate and distinct from other municipal undertakings. It has been found that on the whole a water utility in charge of Commission or Board of Public Works and operated as entities separate from other city undertakings have shown the greatest efficiency and progress. It is true that many difficulties are encountered even under such operation, and this is principally due to the failure of the Common Council to understand the problems of the utility, although in some instances it appears to be due to the fact that petty politics have entered into the operation of the plant.

A knowledge of the principles of efficiency would be of assistance to the operators in many cases and possibly help to eliminate the procrastination and lack of preparation that seems to prevail, particularly in many of the smaller communities. Water utilities are successful in direct relation to the efficiency of their managements.

In this day of consolidation and mass operation, efficient management is said to be one of the essentials in private plant operation if a profitable business is to be developed. If this is true for private operation, it is also true for municipally-owned plants. Municipal water works operation would be further advanced if a central organization devoted to an analysis of its problems were established. Such an organization would provide such increased efficiency in the conduct of the business as is frequently lacking in individual operation. Group purchasing, standardization of equipment, expert engineering, competent legal experience, skilled chemical and sanitary engineering and supervision of financing additions and extensions are a few of the many important services that might be furnished by such an organization.

The one big obstacle encountered in promoting a municipal utility association, is the reluctance on the part of the officials in the smaller communities to contribute even a fraction of one percent of their gross earnings for the purpose of carrying on such an organization. Yet it is the smaller municipally-owned utilities that most need assistance in preparing their records, plans, schedules, etc.

A few of the problems confronting the water departments should be noted. In one locality the Board of Water Commissioners was presumed to have full charge of the operation of the utility and proceeded efficiently for over ten years, extending and developing the business satisfactorily. Under its method of procedure all moneys due the utility for service were collected by a bonded cashier and deposited in the bank to an account "Board of Water Commissioners, City of _____, Wisconsin." No report of these receipts was turned over to the Treasurer, although the accounting system was designed to enable such reports to be made. A new City Treasurer was elected and he insisted that this money was not in his possession in spite of the fact that no check could be drawn on the water works fund without his signature. His contention was that he should carry only one cash account in the bank, but that this one Treasurer's fund would be divided in his cash book among such acounts as "General," "School," "Vocational" and "Utility." While the statutes do not provide that the Treasurer keep a separate utility fund, the Railroad Commission has requested that a separate fund be established by the Treasurer. Where the money is all deposited in one fund, it has been found in many communities, that due to the periodical change in the personnel of city offices, utility funds are used for other than utility purposes, in spite of the fact that such moneys should be kept inviolate.

In one city in the southwestern part of the state the utility books showed a cash balance of $34,586.92 on December 31, 1928. As a matter of fact, this money had been expended by the city so that no utility cash was in the bank on that date. Other communities are found to be in much the same situation due to the appropriating by the city of all excess earnings of the department. When the utility needs funds for extensions the Common Council is some times extremely reluctant to provide such funds if they have to be secured through loans or increased taxes.

Frequently we get letters or verbal complaints from the local Commissions or superintendents, the following being a good illustration:

"Our mayor asked me (Superintendent) if there wasn't some way that I could throw more expense on to the water and electric department as they have gone beyond their means with the General Fund. For some reason they spent all the money they had and forgot all about paying for the street lighting and fire protection. Some time ago we put in a new pump in our old well and when

the time came to pay for it the water and electric department needed some money. I asked them about the street lighting and fire protection and they never thought about it. It was up to the City to borrow some money for the general fund."

We try to clear up situations of this kind by explaining to the Board the proper financial relationship which should exist between the city and the utility.

The Railroad Commission in asking for accurate reports expects some coöperation on the part of those in charge of the small municipal utilities as well as those in charge of the larger ones. However, our experience has been that the tendency in many of the smaller plants is for officials to put off action on everything possible. This may possibly be due to the fact that the person delegated to attend to supervising or actually doing all operating, new construction, bookkeeping, letter writing, etc., simply cannot attend efficiently to the multitude of duties imposed upon him, and therefore is compelled to slight some of them. In view of the fact that water must be pumped and supplied to customers, such tasks as keeping books and writing letters relative to rates, and service, and the making out of annual reports are necessarily delayed or entirely ignored.

One water department in a city not far from La Crosse is operated by direct council control with the records in the hands of the City Clerk. The financial records were found to be so incomplete that action was brought on motion of the Commission to determine who was responsible for failure to comply with the Commission's requirements. Failure on the part of the city to recognize the second principle of efficiency requiring accurate records of the cost of operation of the water works makes it difficult to determine an equitable schedule of rates in the event of a rate case.

The situation in a village about twenty-five miles from Madison was similar to that noted above. The village clerk was paid very little for keeping the utility books and in consequence he kept very inadequate records from the Commissions' point of view. It is impossible to tell from records such as those whether a utility is self-supporting or not, since the financial statements prepared thereform are unreliable.

In some instances utilities have been unable because of the inadequacy of records to establish the need for higher rates, when complete records might have shown the necessity therefor.

A small city in the northern part of the state owning its water and

electric utilities expended over $250.00 in installing an accounting system. About three years later Tax Commission accountants installed a system for handling the city records, and found that the general ledger, consumers ledger, and other records previously installed for the utility had completely disappeared. This municipally-owned utility filed a report blank, purporting to cover the year ended December 31, 1928, that had nothing entered therein except a few of the physical data. It is evident that very little interest was taken in this communiy in securing efficient operation of its utilities.

VARIATIONS IN MOTIVE POWER USED

Most of the older water plants depend on steam for their motive power. Other plants with long years of experience with electric power pumping equipment without auxiliary steam or oil power, have recently installed oil engines. As some plants are rebuilt (particularly the smaller plants) steam is being discarded in favor of electric power operation.

The relative efficiency of these various types of pumping equipment depends a great deal on the size of the installation and on the local conditions to be encountered. Hence the type to be installed should be selected only after a thorough study by competent water-works engineers.

Where a water utility is operated jointly with an electric utility the Commission's classification of accounts provides that the water department should get the benefit of the average cost of electric current delivered at the switchboard. This enables many of such water utilities in the state to operate at a lower unit cost than others whose requirements are much less, but who have to pay for power at the rates charged other private users.

A study made of the comparative cost of electric power pumping per million gallons some time ago showed that the median of thirty-five plants was 0.98 kw. hr. per million foot pounds of water pumped. The median of the average cost per kilowatt hour for each of the same group of plants was 2.36 cents, making a cost of 2.31 cents per million foot pounds pumped. The average head pumped against was 125 feet. Hence on the basis of the above figures 1000 gallons of water would cost 2.41 cents.

In securing the above data only 35 out of 61 water utilities pumping with electric power reported data sufficiently complete and accurate for use. The other 26 omitted to record either the gallons pumped, head pumped against, or kilowatt hours used in pumping.

An instance has come to our attention where several hundred thousand dollars had been expended in installing a new pumping station. Soon after its completion many citizens raised this question: Was the proper investigation made to determine whether the large engines and generators installed (to produce energy to operate electrically driven pumps) would be oversize if all customers were placed on a metered basis?

Meters were eventually installed, the cost in place being about $15,000 as compared with $51,300 for the engines, generators, fuel tanks and oil house. It was then found that about 50 per cent of the cost of the power plant might have been saved if an adequate investigation had been made before the new plant was constructed.

We have in Wisconsin one municipally-owned water utility, with a regularly constituted Water Commission functioning, but actually operated under contract by a private utility. During the several years this arrangement has been effective it appears to have worked out very satisfactorily.

RULES AND REGULATIONS

The Supreme Court has held that unless a utility has on file with the Commission a complete copy of its rates, rules and regulations it cannot legally enforce them. For its own protection, therefore, each utility should establish and file a complete set of rules and regulations governing the operation of the water department and for the enforcing of the rates in effect. Every once in a while a contingency arises which requires a decision to be made by the officials in charge of the department. If a complete set of rules and regulations has been made effective, the utility is protected and the contingency or question arising can be settled in accordance with the regulations approved.

Many of the water departments have rules and regulations embodied in ordinances which should be revised so as to modernize them. A tendency has been noted among many of the water utilities to wait until the necessity arises for the use of a rule before attempting to formulate one that would be applicable. The newer water utilities generally, however, formulate their rules and regulations at the same time the original schedule of rates is established.

An examination of the files in the Commission's office shows that some of the larger and older water utilities could profitably revise the rates, rules, and regulations they are enforcing, while others should enforce their present rules and regulations.

The statutes provide for the collection of delinquent water bills through the tax roll. A surprisingly large number of utilities do not take advantage of this provision. Some utilities have rates that provide a penalty for failure to pay by a certain date, and for discontinuance of service by a later date. If these rules are not enforced (and it is found they are not in many instances) discrimination must result.

The obligation for water rentals is a personal one, which does not run with the land. The matter appears to be covered by the decision of the Supreme Court of Wisconsin in Willow River Power Co. vs. R. R. Comm., 220 N. W. 173, decided January 18, 1928, where the Court held that a present owner of premises whose former owner was delinquent in his obligations cannot be required to meet the obligations of the former owner as a condition precedent to service. From the above, therefore, it is apparent that while delinquent bills may be collected through the tax roll, if this practice is not followed, service to the premises cannot be refused where there is a change of ownership.

There should be a definite collection period established and after that period has passed no more collections made until the next period arrives. Those in charge of the customers ledgers cannot possibly handle their work efficiently if they have no time between collections in which to balance their books and bring forward the arrears. The smaller water utilities as a rule collect bills continuously. That is, each new batch of bills contains no reference to any arrears which may exist. In one town of a population of about 1200 we found some $3000 of arrears carried on bill stubs only, due to this method of billing.

A lack of interconnection between certain records has been noted in many of the utility offices and the attention of those in charge called thereto and improvements suggested in order to simplify and clarify the accounting procedure. For example, in one instance no interconnection was found to exist between the daily record of cash receipts and the charges for service in the consumers ledger. There was no connection visible between the receipts by classes of customers, as shown in the cash book, and the itemized daily cash payments made by customers, as listed or entered in the single column "day book" which purported to take the place of the standard "Report of Cash Collections."

No credits were entered in the customers ledger from the itemized

daily collection report book. During the course of an examination made by one of the Commission's accountants, it became necessary to look up the payments made by a customer, who had paid by check and held no receipts. This involved a detailed examination of each entry on each page in the "day book," covering over a month's transactions, which took about half an hour. Had the standard tabular or unit account customers ledger been in use, either would have shown the information desired in less than two minutes.

A customers ledger, each page of which will show quarterly charges for water service to one customer, but can be used for about thirty years, which recently came to our attention, appears to be carrying this type of record a little too far. At the most, a four year record appears to be better adapted to changing conditions and this record should show in addition to the charge for water, the meter readings, penalties charged, discounts and allowances made, cash paid and date of payment, and any arrears carried forward to a subsequent billing period. Failure to keep the proper records is not conducive to the most efficient operation of a water utility. The adoption of machine billing and posting of customers' accounts has been a big step forward for many of the larger utilities.

FREE WATER SERVICE

Why a water utility should receive credit for the service it supplies is evidently not clear to the officials in charge of many municipally-owned water plants.

In one city in Trempealeau County the municipal water department furnished water to the electric department for cooling the two Diesel engines used in generating current. No record was kept of the enormous quantity of water used (in some installations found to vary from 7 to 18 gallons per kilowatt hour generated) so that the water department could receive credit therefor. All pumpage was recorded and the cost thereof which included electric energy used, was borne by the other customers, whereas at least the bare output cost of the water pumped and used by the engines should, under the Commission's classification of accounts, have been charged to electric plant operation and credited to water department pumping expense account "Production Expenses Transferred—Credit."

In some localities service is supplied by the water department to the city for fire protection service, street and sewer flushing, drinking fountains, hospitals, schools, etc., without the departments ever

receiving any actual cash for such service. Many small water departments not only receive no cash for these various services but no revenue credits are set up covering same. Efficient operation should not countenance practices such as these.

RATES

A municipally-owned water utility is more or less a mutual business. Its usefulness depends upon the manner in which it operates and the service it supplies. Whatever hinders this usefulness is a detriment to the community. One of the greatest hindrances with which we are confronted right now is the flat rate evil. A schedule of flat rates in effect is practically an invitation to the customer to waste water.

Water wasted, that is water pumped and not fairly paid for, is just so much loss to the treasury of the utility from which operating expenses and return on the money invested is being paid. The wasteful consumer usually thinks the little water he is letting run away uselessly is a mere drop in the bucket as compared to the quantity available, but small leaks always mean a big loss when we consider that they are constant.

The water department's income might not be increased by having all customers metered, in fact it might be decreased, but the expenses would also be greatly descreased because metering means leak-stopping and the money now expended to supply wasted water would be available either for return on the capital invested or for reducing rates.

Many of the smaller water utilities in the state are still serving the majority of their customers on an unmetered basis and this fact is reflected in the small amount of surplus produced by operations at such plants for return on the capital invested. There appears to be no equitable basis of determining a rate for unmetered service as one designed to cover the average cost per customer may allow one user to obtain many times the quantity of water another user might require. Efficient operation then demands practically universal metering.

An examination of a compilation of water rates effective in Wisconsin shows a wide variation in type. The character or type of schedule will depend upon the efficiency of the plant.

There are two main classes of service supplied by a water works, namely, Fire Protection Service and General Service. Their relative importance need not be gone into, except to note that in the smaller communities investigation has shown that over 52 percent of the

investment, on an average, is made to supply fire protection service. It is evident, therefore, that this class of service should carry at least 50 percent of the fixed charges plus its proportionate share of the output and standby costs.

General Service may be either metered or unmetered. Most of the flat rates that are still in effect are a continuation of those in use at the time the Public Utility Law was established and appear to have been based more or less on arbitrary estimates of what the service was worth rather than upon any cost study. As stated before, the most progressive plants are gradually metering all customers and thus eliminating this element of inefficiency.

A schedule of rates for metered service may consist of a minimum charge, graduated according to size of meter and covering a fixed quantity of water, together with output charges per million gallons or per 100 cubic feet for quantities used in excess of the minimum. In some localities a service charge is in effect plus output charges for water actually consumed. The service charge is designed to cover the customer and fixed or demand costs, which are prevalent throughout the year whether any water is being used or not. This latter type of rate is found in many of the larger water utilities in the state. A schedule in which is incorporated a graduated minimum charge, however, appears to be more easily understood, particularly in the smaller communities, and may be made effective without causing as much confusion in the minds of customers as the service charge type of schedule.

The character of the territory supplied, and the local conditions encountered, have much to do with the practical working out of the rate schedule. It appears that in a village like Shorewood (Milwaukee), for example, where practically all the customers supplied are residential users, a straight meter rate of say 12 cents per 1,000 gallons may be satisfactory. However, where large manufacturing concerns require great quantities of water, experience and analysis indicate that a graduated schedule is equitable and tends to develop business.

There are only sixteen communities in Wisconsin, out of 264 supplied with water, with regressive rate schedules still in effect, relics of the prevailing type of rate in the pre-regulatory period. (Berlin, Cadott, Chippewa Falls, Gays Mills, Johnson Creek, Kilbourn, Lake Geneva, Mayville, Menomonie, Prairie du Sac, Shullsburg, Sun Prairie, Superior, Westby, Whitehall, Wilton.) These regressive rates have not been eliminated due to the fact that the municipality

has made no application for revision and evidently only a very small number of customers are adversely affected by their continuation. In view of the fact that most meter schedules at one time were regressive, the present showing is an indication of progress in water utility operation.

RETIREMENT RESERVES AND FUNDS OFFSETTING SAME

A water works property is made up of about as enduring material as can be found—buildings, filters and reservoirs of concrete and masonry and miles of cast iron pipe buried deep in the ground. All this is long lived property. The pumps and other station equipment, meters and services, of course, have a shorter life. On an average, a very small percentage of the physical value of the depreciable property need be set up annually to accumulate a reserve to care for retirements as they become necessary.

All of the Class A and B water utilities and a large number of the smaller are setting up the proper retirement reserves. Only a few, however, have gone a step further and built up a fund offsetting this reserve. There are a few jointly operated municipal water and electric utilities that have set aside very substantial funds which are available as cash or have been invested in readily marketable securities. Some of these funds range between $60,000 and $100,000.

In most cases, however, the fund offsetting the retirement reserve has been invested in additions and extensions to the plant. Which basis is the best and most efficient is a debatable question. The necessity for a special fund of this kind is not quite as apparent in water works operation, with its equipment reasonably free from accidental injury, as in the case of electric or telephone utilities subject to such contingencies as sleet storms.

SELLING WATER SERVICE OUTSIDE THE CITY'S CORPORATE LIMITS

Many of the municipally-owned utilities have consistently refused to retail water outside the corporate limits of the municipality. Others have developed a large volume of business and increased their revenue considerably by either retailing or wholesaling water to outside communities.

It appears that the municipally-owned utility cannot be compelled to assume such an undertaking against its will, nor can the authorities of an adjacent political unit be compelled to grant a permit for the municipal water department to extend its mains should it desire to do so, that action being discretionary.

It has been said that there is not the effort on the part of municipalities to stimulate water sales that is found in privately-owned systems. It is a fact that a great many small municipally-owned water systems that could sell a great deal more water and increase their earnings from existing equipment with no increase in operating expense except for power, station supplies and maintenance, make no attempt to secure the additional business. As an example, not far from Madison is a village with somewhat constricted corporate limits. There are quite a few houses adjacent thereto that want service as well as a golf club that requires a considerable quantity of water. The Board has consistently refused to extend service to these outside residents, their principal reason being that there are still a few citizens within the corporate limits not supplied.

When once a utility begins to supply a service to the general public it cannot easily discontinue it on its own motion. The statutory obligation of a public utility is to render reasonably adequate service at all times and it cannot abandon that function without the consent of the state. (Attorney General vs. Railroad Company, 35 Wis., page 425). The property being affected with a public interest it follows that the operator cannot at its option divest that interest merely by refusing to continue the service.

If a municipal water department finds it can heat a few municipal buildings located rather close to its boiler plant it can discontinue this service at will as it is discontinuing a service to its owner. If it finds that with the existing equipment private buildings located along the heat mains can be served with but little additional out of pocket expense and they are connected, the water department then in reality becomes a joint utility and assumes certain obligations to serve any person desiring steam service. The rates charged for steam, which may be exhaust or live steam, may be rather low due to the by-produce character of the supply. A situation can easily develop thereafter whereby the water department might be able to effect a considerable saving in pumping expense by buying electricity and replacing its steam pumps with electric-driven pumps with oil power standby. With a steam or hot water heating system saddled on to it, however, a nice problem arises as to whether the heating customers can be made to carry all the boiler room operating expenses plus fixed charges on such equipment, without raising the rates prohibitively.

A water utility should make an extended investigation into the heating business before undertaking it, as the financial success of most heating utilities has not been very marked.

MAIN EXTENSION POLICIES

The efficiency of the various water works systems in use throughout the state is reflected in the policies followed in extending mains to serve new customers.

There are a number who assess the abutting property owners for a part of the cost in accordance with the provisions of section 62.19, R. S. Others make extensions of existing mains for applicants at the expense of the water department for a distance of 66 feet for each new customer along the line of the extension (not including in such distance intervening cross streets). Where any extension desired is for more than 66 feet per customer, the applicant or applicants are required to advance the excess cost which is refundable when additional customers are connected.

In certain localities the Board will authorize the extension of mains, when funds are available for such work and when the prospective annual income from same, in the judgment of the Board, will justify the expenditure. This income is required to be not less than 10 percent upon the cost of the expenditure.

In one community many thousands of dollars of mains were laid at the expense of the department. These mains were laid, however, upon petition of property owners in which the latter signed an agreement to defray such cost, either by paying in cash each applicant's respective share of the estimated cost or in lieu of such cash payment by executing and delivering to the city water department a special Improvement Lien against each applicant's respective premises abutting upon the street. While over $40,000 of these liens were executed only $3,000 were actually exercised due to the department's having sufficient funds without recourse to the liens.

One of the provisions set forth on the petition signed by the applicants for water service was to the effect that, if such special improvement liens were exercised, the entire revenue derived from such mains and hydrants should be proportionately applied annually for at least ten years, toward refunding to applicants any money advanced or towards satisfying any liens given. In addition to the revenue credit the water department was to increase or augment the amount of such revenue to be applied, by adding one-third of the sum of same out of its own general funds. This scheme certainly shows originality and initiative on the part of the Board of Water Commissioners and enabled it to finance main extensions when its own funds were low.

Many of the water utilities have had to decide whether it was more

economical and efficient to lay an extensive system of mains in new territory or when a new utility is established as has happened in several communities (Town of Allouez, Genoa City, Gillett, etc.), or to lay mains only as required, piecemeal, so to speak. In the first instance the utility must carry heavy fixed charges from the start, hence the rates must be placed at a much higher level than where the original installation is kept down.

PROPER EQUIPMENT

There appears to be a reluctance on the part of those in charge of many of the water utilities to make periodical surveys to determine the adequacy of their water supplies, pumping equipment, storage facilities, etc. This is not true of all plants, of course, but in certain localities it has been noted that the superintendent has had to fight continually for expenditures which would enable him to give the immediate, reliable, adequate and permanent service which should be available.

When an examination discloses conditions as outlined below, it is evident that city officials have been somewhat delinquent in their duties as operators of a business having, as this one did, $1,325,000 invested therein.

1. The water supply is inadequate.
2. The water storage capacity is inadequate.
3. The central pumping plant is inefficient and should be electrified.
4. Operation of the wells on the ——— side should be made automatic.
5. The accounting system should be modernized.
6. The rate schedule should be adjusted.

None of the principles of efficiency were given much consideration in this community, it appears, from the above summary.

Instances have been known of communities where only one well was in use, equipped with a deep well plunger pump which got out of order through continual use. There being no duplicate equipment or water supply, not only was the community endangered by lack of water for fire fighting purposes, but the health of the citizens was endangered before repairs could be made.

In many small communities you will find a creamery, condensery or canning factory which requires large volumes of water, all of which the utility cannot supply with its limited well and pump capacity. A question arises then, where the creamery or other customer installs a well of its own, shall a cross connection be made between the private

and public water supply. With the proper check valves there are many localities in which the efficiency of operation of the water works would be enhanced by such connections, as in cases of emergency an interchange of service could be effected.

The "safety first" policy of a water utility should extend from the purification of its product to the safe driving condition of its trucks and automobiles. Several utilities have been held responsible for accidents because they failed to provide some small detail of safety equipment. For example, in cutting cast iron pipe no glasses were furnished, and an employee was struck in one eye by an iron chip. If the department provides the equipment and the employee fails to use it, the department has at least done all it could to operate safely.

The mentality of employees differs widely and recognition of the qualities that might interfere with the alertness necessary to avoid hazard is a big factor in the reduction of accidents and the promotion of efficient operation.

An employee who has been on the job for several years hangs his sweaty shirt over the railing enclosing the engine fly wheel, so that it will be dried by the air currents set up by the revolving wheel. It is sucked down into the pit when dry. With very little clearance available he lowers himself into the pit while the wheel is revolving to recover the shirt. Would you continue to employ a man of that kind? The superintendent of the plant where this happened discharged him.

This discussion has necessarily been confined to only a few of the principles of efficiency and many phases of the problems arising in water works operation might be elaborated upon with respect to their application to this subject. However, such material as has been set forth here has been presented for the purpose of offering some beneficial suggestions and constitutes an attempt at constructive criticism.

ACTIVATED CHAR AS A DEODORANT IN WATER PURIFICATION[1]

By George R. Spalding[2]

Experiments being conducted in the laboratories of the Hackensack Water Company at their New Milford, New Jersey, purification works indicate that small quantities of activated char in finely divided condition may be used in conjunction with the usual alum coagulation process thereby furnishing a means of removal of odors due to micro-organisms, phenolic substances, and the ordinary odor producing substances present in surface waters.

Such substances are undoubtedly present in extremely small amounts so that the quantity of absorptive agent, such as activated char, which would be required for their removal might also be expected to be small. The action of ordinary aluminum hydrate floc in removing odors is well known and under certain conditions such removal takes place in appreciable degree.

Effective deodorizing by an absorptive agent such as activated char requires (1) char to be very finely pulverized (2) to be very completely distributed in the water by effective mixing and (3) sufficient period of contact provided for proper absorption.

Assuming the foregoing hypotheses to be correct the following bottle experiments have been made with results as noted. In all experiments the use of activated char simultaneously with alum has resulted in improved flocculation.

1. One gallon bottles of river water were dosed with liquid from a vigorous culture of Oscillaria. The resultant water gave an odor, 5 swampy 2 fishy. These gallon bottles were treated with 0.5 g.p.g. of finely divided activated char, mixed thoroughly, allowed to settle three hours and filtered. Effluent showed entire absence of fishy odor and swampy odor reduced to 2.0.

2. Sample of water as in experiment No. 1 treated with 0.5 g.p.g. activated char and 1.5 g.p.g. alum effected entire removal of odor in one hour.

[1] Presented before the New York Section meeting, May 2, 1929.

[2] Sanitary Engineer, Hackensack Water Company, New Milford, N. J. In collaboration with Paul Tamer, Chemist.

3. Removal of phenols. Gallon samples of water with concentration of 1 p.p.m. pure phenol. Addition of 0.5 g.p.g. activated char and 1.5 g.p.g. of alum effected complete removal of odor and taste after contact period of one hour.

4. Removal of aldehol (No. 3 "Nuchar"). Aldehol is an alcohol denaturant produced by oxidation of kerosene by a catalytic agent. Has an exceedingly strong odor resembling automobile exhaust gases.

Gallon bottles of water with concentration of 1 to 4 million aldehol.

One grain per gallon of char with 1.5 grain of alum effected practically complete removal of odor and taste.

One half grain of char with same alum dose gave nearly as good removal.

Less than 0.5 grain of char appeared to be insufficient for complete removal.

Straight alum without any char produced slight odor and taste removal.

5. Removal of aldehol (No. 2 "Nuchar") (less highly activated product). Gallon bottles of water with aldehol in concentration of 1 to 2 million.

One and one-half grain alum with one grain of char gave entire removal of taste and odor. Same alum dosage with 0.5 grain of char removal all odor but left faint taste. Same alum dose with 0.25 grain char removed perhaps 75 or 80 percent of odor and taste.

Further experiments are being conducted to determine the efficacy of these chars in removal of phenolic and cresolic tastes, their action on chlorophenols and more complete studies of quantities required in removing the ordinary odors and tastes of surface waters.

A test of several days duration in the actual application of activated char to our coagulation process is to be conducted in the near future.

SUPPLEMENTARY NOTE

Actual application of pulverized Nuchar #2 in conjunction with routine alum dosage of raw water has been carried on over a period of 23 days during March, 1930, at the plant of the Hackensack Water Company. The daily output of water is about 35 million gallons. Raw water during this period carried an odor characterized as distinct-fishy due to asterionella, dinobryon and uroglena. Dosage of Nuchar #2 in the amounts of 1.2 parts per million or 10 pounds per million gallons removed this odor entirely, producing an

effluent limpid in character and greatly improved from the standpoint of palatability. The Nuchar used was finely pulverized, passing a 300-mesh sieve and was applied to the coagulant mixing chamber through an ordinary dry feed machine with ejector discharge.

REPORT OF SECTIONAL COMMITTEE ON SPECIFICATIONS FOR CAST IRON PIPE

The Sectional Committee on Cast-Iron Pipe is organized under the procedure of the American Standards Association under the joint sponsorship of the American Gas Association, the American Water Works Association, the New England Water Works Association and the American Society for Testing Materials. The scope of the committee includes a unification of specifications for cast iron pipe, elimination of unnecessary sizes and varieties, consideration of a scheme of metallic pipe and fittings applicable to all common mediums, and methods of making up joints. New standards for cast iron pipe and special castings are being developed, the work having been assigned to three technical committees with sub-committees as follows.

WORK OF TECHNICAL COMMITTEE I ON DIMENSIONS:
W. C. HAWLEY, CHAIRMAN

Sub-Committee I-A on Dimensions of Barrels of Sand-Cast Pipe, L. B. Smith, chairman.

Sub-Committee I-B on Bell and Spigot Dimensions, Lugs and Harness, John C. Prior, chairman.

Sub-Committee I-C on All Types of Pipe Except Vertical Sand Cast, F. H. Stephenson, chairman.

Sub-Committee I-D on Fittings for All Types of Cast Iron Pipe, C. Haydock, chairman.

To Technical Committee I has been assigned the work of reviewing schedules of dimensions and weights of pipe and fittings. It seeks to simplify these schedules by eliminating unnecessary sizes, weights and patterns. It is carrying on tests and investigations to determine moot questions such as proper thicknesses of barrels of pipe to resist static and water ram pressures, external pressures from earth and vehicular loads, stresses due to handling, to improper supports, to projecting ledge and frozen ground, etc. Consideration is being given to possible improvements in design of bells to resist stresses

due to caulking, settlement, etc., and the design of lugs and harnesses. Various kinds of pipe cast in rotating molds, Universal, McWane, and other kinds of pipe not cast in vertical fixed sand molds are also being considered. Consideration is being given to fittings of all kinds, with a reduction in number and variety if possible, to strength of tees, crosses, Y-branches and sharp curves which because of their shape are subject to special stresses from hydraulic pressure.

Tests have been made at the University of Illinois by Prof. M. L. Enger and under the direction of the technical committee, on strength of pipe, using methods similar to those inaugurated by Prof. A. N. Talbot which have increased available knowledge of the properties of cast iron pipe. Trench-load tests are being made at Iowa State College by W. J. Schlick, under the direction of the technical committee, which will give definite information on some of the questions on earth loads on which there has been much discussion in the past. These include tests on the supporting strength of 20-inch pipe, with and without internal pressures with different arrangements of bearings, both of single pieces and jointed pieces, which will give better knowledge of the stresses in the pipe when in the ground under normal earth loads, under heavy cover, and when the support under the pipe is for any reason poor.

The quality of the metal in the pipe used in these tests is determined from records of tests of 2- by 1-inch bars cast from the heat; statement from the foundry making the pipe of the make-up of the charge, size of cupola, air pressure and quantity of air, and rate of melting; and from chemical analysis, if available, of metal from casting of similar thickness from the same heat.

To obtain desired information for the work of Sub-Committee I-D, two series of tests on fittings were put under way in 1929. The fittings were made from dimensions which are under consideration for adoption and which would give a new set of standards for fittings shorter in their laying lengths than the present standards of the American Water Works Association. They would be virtually of the same laying dimensions as the present American Society of Mechanical Engineers' flanged fittings for 125-lb. pressure. The first series of tests on these fittings is being made at the University of Illinois by Prof. M. L. Enger and is to determine the bursting strength of the fittings under water pressure; the second series is being made at Cornell University by Prof. E. W. Schoder and is to determine friction loss through the fittings at varying velocities and under a number of

different conditions as to water leaving the fittings from their various outlets. In making both these series of tests, tests will be made at the same time on corresponding A. W. W. A. standard fittings.

WORK OF TECHNICAL COMMITTEE II ON METALLURGY, PROCESSES AND TESTS: M. L. ENGER, CHAIRMAN

The work of this technical committee is organized under the following sub-committees:

Sub-Committee II-A on Raw Materials and Melting Practice, W. Flannery, chairman.

Sub-Committee II-B on Metallurgy and Chemistry, R. Moldenke, chairman.

Sub-Committee II-C on Physical Tests and Test Specimens, S. E. Killam, chairman.

Sub-Committee II-D on Experience, J. Goodman, chairman.

To Technical Committee II has been assigned the task of investigating pig iron and other raw materials entering into cast iron for pipe, and acceptance tests relating to the strength of the pipe and the quality of the metal in them. It will consider the injurious effect on the quality of cast iron caused by forced output from blast furnaces and some cupolas, the quality of some domestic and imported pig iron now on the market, and practical limits in the use of scrap of various kinds and quality of coke and limestone. All chemical analysis of metals for the sectional committee and technical committees will be made by this committee. It will consider the desirability of chemical specifications in general for composition of metal in the finished castings. It will assemble and analyze data on experience with pipe and failures by fracture in service with particular relation to evidence as to failures resulting from quality of iron or processes used.

The tests on pipe which have been made at the University of Illinois by Prof. M. L. Enger and described above under the work of Technical Committee I, will to an important extent help the work of Technical Committee II in developing acceptance tests to be specified.

WORK OF TECHNICAL COMMITTEE III ON CORROSION AND PROTECTIVE COATING: L. P. WOOD, CHAIRMAN

The work of this technical committee has been organized under the following sub-committees:

Sub-Committee III-A on Corrosion of Cast Iron Pipe, H. O. Forrest, chairman.

Sub-Committee III-B on Organic Coatings (Coal Tar, Asphalt, etc.), S. R. Church and C. E. Trowbridge, technical and executive chairman, respectively.

Sub-Committee III-C on Inorganic Coatings (Cement Linings, etc.), J. E. Gibson, chairman.

Sub-Committee III-D on Water Corrosion Experience.

Sub-Committee III-E on Soil Corrosion Experience, J. R. Baylis, chairman.

Sub-Committee III-F on Hydraulics, M. L. Enger, chairman.

To Technical Committee III has been assigned the study of causes and mechanism of corrosion of cast iron pipe exposed to soil or water, and of practical methods of reducing or eliminating such corrosion so far as this can be done at the pipe shop. Control of corrosion by treatment of soil or water, field coatings, metallic coatings, and corrosion due to stray-current electrolysis are outside the province of this committee. It will prepare specifications for the cement lining and coating of cast iron pipe and fittings, including mortar and concrete and other inorganic linings and coatings, if any, excluding, however, purely metallic coatings; and specifications for the coating of cast iron pipe and fittings at the pipe shop with organic materials. The committee will collect and digest the experience of pipe users with water corrosion of cast iron pipe, soil corrosion not caused by stray current electrolysis, and correlate this experience with these two types of corrosion with the properties of the iron, the water or the soil, and the coatings. It will study the territorial extent of soil corrosion troubles, the annual tonnage affected, the cost to the pipe user, and what he can afford to pay to avoid or minimize soil corrosion. Determinations will be made of the relative carrying capacities of cast iron pipe with various coatings, both new and after exposure to active waters. The necessary over-size of pipes variously coated to give the same capacity at various ages in active waters as a corrosion-free and tuberculation-free pipe will be determined, and the

money value of better coatings estimated. Field or laboratory gagings, if found necessary or desirable, will be organized, and the committee will advise respecting any other hydraulic aspects of the corrosion and coating problem.

Tests have been made at the Massachusetts Institute of Technology by Prof. H. O. Forrest on corrosion in water of cast iron pipe of various chemical compositions, the specimens being kept immersed up to a maximum of 300 days, and the water being allowed to run without interruption past the specimens which are kept rotating. Knowledge gained from the loss in weight of the pipe from water corrosion and from its appearance and character of corrosion, taking into account the constituents of the metal and the nature of the water, will give valuable information in regard to both pipe and coating.

Preliminary conclusions from these tests as well as other investigations were mentioned in a paper by Prof. Forrest before the American Society for Testing Materials in June, 1929, and the following is the synopsis given at the beginning of this paper summarizing the preliminary results.

> The factors affecting the corrosion of cast iron include not only the characteristics of the metal itself, but also, to a greater extent, the composition of the corroding medium and the type of protective coating employed. The coatings may be either applied or precipitated upon the metal. Preliminary tests at the Research Laboratory of Applied Chemistry of the Massachusetts Institute of Technology conducted under conditions comparable to service conditions indicate only small differences in the rates of corrosion of cast iron pipe manufactured by different processes. These indications point to the need for use of proper protective coatings applied before the pipe is put into service or else for treatment of the corroding medium with chemicals to bring about precipitation of protective scales or films. The primary requisites for good coatings are impermeability to water and freedom from pinholes so that the corroding medium cannot reach the metal surface, since a few holes in a pipe are almost as serious as complete corrosion.
>
> Corrosion tests in soils point to the fact that in general the nature of the soil rather than the types of metal of certain classes is the factor which governs the corrosion rate. Cast iron, in the majority of the cases reported, is slightly superior to steel or wrought iron in corrosion resistance in the atmosphere. There are many cases in which cast iron is superior to other ferrous materials, for example, in handling various chemical materials such as strong sulfuric acid, dry sulfur dioxide, organic distillates, etc.

Referring to the first of the two paragraphs in quotation given above, the major consideration in nearly every case from the water works standpoint is prevention of tuberculation and consequent re-

duction of carrying capacity, and for this purpose also coatings without pinholes are essential.

Sub-Committee III-B has adopted a program for experimental work on organic coatings, principally tar, to be made at the new shops of the American Cast Iron Pipe Co. at Birmingham, Ala., under the general direction of S. R. Church, chairman of this sub-committee.

Sub-Committee III-C has adopted a program for work on tests in service of cement-lined pipes. These tests will be made in the system of the Birmingham Water Works Co., Birmingham, Ala., under the direction of J. E. Gibson, chairman of this sub-committee, and the tests will cover a variety of conditions with mix of the mortar lining varying from the present rich mix of three parts of cement to one of sand down to as lean as one cement to two and a half of sand. Thickness of lining will vary from quite thin up to ½-inch thick, and the tests will also cover different methods of curing and use of retempered mortar.

GENERAL

On all of these tests, the pipes come from foundries in different parts of the country and are not specimens picked for the tests but are the ordinary run of pipe, with the view that all tests should give information which will apply to average conditions. Complete information is recorded of all details of manufacture of each piece of pipe so that everything possible will be learned and published to connect cause and effect of all phenomena observed.

Information received in replies to a general questionnaire on cast iron pipe sent out by the sectional committee, has been summarized in tabular form in a book and distributed to the members of the sectional committee and its technical and sub-committees, in connection with the work of preparing new specifications.

A. V. RUGGLES,
Executive Assistant to Chairman,
Sectional Committee.

THE DEVELOPMENT OF THE MIDDLETOWN, N. Y., WATER SUPPLY[1]

By J. A. Korschen[2]

The city of Middletown, N. Y., has a population of about 21,500 and is located about seventy miles northwest from New York City in the County of Orange and along the foothills of the Shawangunk Mountain range.

In 1866 when the city was a village, a few far-sighted citizens, realizing that the future growth of the community would depend largely upon a good water supply, determined upon a municipally owned system. After considerable discussion a site was finally selected and the citizens voted a bond issue of $75,000.00 for the construction of what is now known as Monhagen Reservoir and also a 10-inch concrete pipe line from the reservoir to the village. This work was completed in 1867. The first annual report of the water board was made in 1868 showing that the Middletown water works consisted of Monhagen Reservoir, about six miles of concrete water main and 56 hydrants. This report further stated that the gross annual income was about $6000.00.

This reservoir is 161 feet above the business section of the city, covers 74 acres, has a maximum depth of 24 feet and contains when full 296,000,000 gallons of water. Its drainage area in 426 acres and it is located about two miles west of the city. The water is clear with no turbidity, and the hardness equivalent to carbonate of lime before boiling is 27.

After a couple of years Monhagen Reservoir had not filled up as our forefathers had expected, in fact it was far from full, and they commenced to look around for some source to augment the supply in the reservoir. Finally in 1873 a large pump was installed somewhere along the Shawangunk Kill and 3½ miles of wood-stave pipe were constructed from the Kill to the reservoir. The cost of this work was about $60,000.00. Due to some legal difficulties encoun-

[1] Presented before the New York Section meeting, May 4, 1928.

[2] Commissioner of Public Works, Middletown, N. Y.

tered when they started to pump water from the Kill this new construction lay idle for six years and finally when these difficulties were overcome new obstacles arose. This wood-stave pipe, having been idle for such a long period of time, had shrunk and warped and leaked badly in its entire length. Furthermore they were not allowed to take the quantity of water that they had expected to pump from the Kill. With great disappointment this scheme was shortly abandoned and the pump and pump site sold for $1000.00.

Those pioneer days were full of disappointments. The next trouble encountered was the necessity of replacing the 10-inch concrete main from the reservoir to the village with a 12-inch cast iron pipe. This was due to the fact that the leakage was so great that the line was considered a complete failure. This replacement was made in 1879. Shortly thereafter all the concrete pipe was replaced with cast iron pipe.

During those trying years it was customary for the water board to apply to the citizens for financial aid in running the water department and it was not until 1883 that the department became self-supporting.

Middletown continued gradually to gain in population and it was only a matter of time when a further supply would have to be obtained. The residents were commencing also to build homes on higher points in the city and the Monhagen supply was unable to furnish adequate pressure at those points. Again our far-sighted forefathers got busy and wisely decided that rather than pump water to these points they might better look around for a higher source of supply which would give them additional water and furnish a gravity flow. So in 1891 Highland Reservoir was constructed and a 12-inch cast iron pipe line was laid from this point to connect with the 12-inch pipe starting at Monhagen Reservoir and a new 20-inch cast iron pipe line was laid from Monhagen Reservoir to the city.

Highland Reservoir is located about 4 miles southwest of the city. It is 239 feet above the business section, covers 110 acres, has a maximum depth of 20 feet and contains when full 517,000,000 gallons of water. Its drainage area is 341 acres in addition to the water area. The water is clear with no turbidity and the hardness is 25.

Due to some very dry seasons the water in Monhagen Reservoir became very low, so in 1893 several wells were driven in a field just outside the city limit. These wells were hooked up with a pump and the water pumped into the 20-inch main. This operation how-

ever proved a disappointment for it was only able to deliver about one half of the water expected. The cost of this plant was about $9000.00, did not come up to the expectancy of the Board and a few years later was abandoned.

The next problem confronting the Board of Water Commissioners was the subject of filtration. Realizing the evil effects of impure water on the health of the community and appreciating the fact that a city supplying an abundance of pure water attracts population and manufacturing enterprises, the Board resolved to take action toward improving the quality of the water supply, and to that end a committee was appointed in 1898 to investigate fully the various methods of filtration.

Finally, in May, 1899, after having given the matter careful attention and having studied the character of the impurities of the water, probable cost and the loss of head of the different methods of filtration, the Board unanimously decided in favor of mechanical filtration and adopted the combined pressure and gravity system. The contract for the construction of the plant was awarded to the Continental Filter Company of New York. The plant was started in 1899 and completed in 1900. It consisted of four steel pressure filters, each having a capacity of 250,000 gallons per 24 hours, and four wooden gravity filters having a daily capacity of 500,000 gallons each, making the total filtration capacity of the plant 3,000,000 gallons per 24 hours. Underneath the four gravity filters was constructed a clear water well having capacity of 98,000 gallons. The building, a brick structure, is located alongside of Monhagen Reservoir and both reservoirs were connected up with it.

With the failure of the wells as mentioned before, a few dry seasons and an increase in consumers, it became apparent to the Board that it was only a question of time when some further expansion was necessary. Matters became worse and worse, the supply became very low and a water famine seemed one of the possibilities. Prompt and effective measures were taken to protect the rapidly diminishing store of water. After fully considering the condition of the water supply, the Board resolved that it was its duty to recommend at once that steps be taken toward providing an additional water supply. Several eminent engineers were engaged to go over the field and report upon various plans for increasing the city's supply of water. While these plans differed more or less in detail, the general outline of the plans was the same. All united in the wisdom and necessity of

building a storage reservoir on the site now known as Shawangunk Reservoir. The next step to decide was as to the best place to secure water to fill this reservoir in addition to the water obtained from its water shed. Shawangunk Kill was finally selected as the best source of supply.

In 1901 the following work was started: Shawangunk Reservoir was built by constructing three dams known as the Stewart, Woodward and Greenleaf Dams. These dams are earth filled having a masonry core wall and the face lined with stone. At a point on the Shawangunk Kill, about 8,200 feet southwest of Shawangunk Reservoir, a collecting reservoir was established by building a small dam known as Kinch Dam. From this point the water was conducted to the reservoir by means of a 24-inch cast iron pipe. The next step was the construction of a 20-inch cast iron pipe about 18,600 feet long connecting Shawangunk Reservoir with Monhagen Reservoir, the water emptying into the latter through an aerator. All this work as stated above was started in 1901 and completed in 1902.

There was some trouble encountered in the construction of the 20-inch line. Somewhere along the middle of this pipe line there was about 2000 feet of a 25 foot cut through rock. The contractor wisely completed the line on each side of the cut and then started to tunnel through the rock. He soon became discouraged and finally threw up the job and the work was completed under the supervision of the Water Board.

Shawangunk Reservoir is located about five miles southwest of the City and is 211 feet above the business section, covers 101 acres, has a maximum depth of 25½ feet. The drainage area is 422 acres, exclusive of the water area and the water is clear and has a hardness of 26.

After obtaining this increased supply of water it soon became necessary to increase the capacity of the filter plant and in 1909 four reinforced concrete gravity filters were installed in the building, increasing the filtration capacity to 5,000,000 gallons per 24 hours.

In 1911 the city charter was changed and the Water Board was abolished, the water department being placed under the direction of a Commissioner of Public Works.

As mentioned before in this description, Highland Reservoir is connected with the filter plant by means of a 12-inch cast iron pipe. The total length of this line is about 10,800 feet and the first 6000 feet from the reservoir was laid on a grade of 1 foot in 1000 feet.

The balance or 4800 feet was laid on a grade of 1 foot in 70 feet. During the year of 1915 it was noticed that the consumption on the Highland system had become so great that the pressure at the filter plant was greatly reduced. We found that the consumers were using more water than that delivered by the 12-inch line at the plant. It was then decided to lay a 20-inch cast iron pipe from the reservoir, a distance of 6000 feet, towards the filter plant and connect it with the old 12-inch pipe. This work was completed in 1915 and materially improved the pressure on the Highland system.

As the city was gradually growing the consumption of water naturally increased and as the four original wooden filters had become pretty well worn out, it was decided to replace them with six reinforced concrete filters, each having a capacity of 500,000 gallons per day. Two more steel pressure filters were added to the Highland system, each having a capacity of 250,000 gallons per day. These installations were completed in the early part of 1921 and increased the filtration capacity to 6,500,000 gallons per 24 hours.

A reinforced concrete clear water well was also constructed just outside the building. This well is covered and is 75 feet square and 6 feet deep with a capacity of 250,000 gallons.

PITOMETER SURVEY AND CLEANING OF MAINS

During 1925 the Pitometer Company of New York made a survey of our entire water system. All the main supply lines were tested for leakage. The Venturi meters in the filter plant were tested for accuracy. The city was divided into districts and a measurement of the flow into each district was taken for 24 hour periods. All meters 3 inches and larger were tested in place. Several undiscovered underground leaks were located and repaired and leaking plumbing fixtures were also located and repaired. The Pitometer Company also gave the city some valuable recommendations in connection with the future development of its distribution system.

About this same time Kinch Dam on the Shawangunk Kill was raised 5 feet, thereby holding back more water in the collecting reservoir and storing a lot of water which would otherwise run to waste. The three dams on Shawangunk Reservoir were likewise raised 2½ feet, by permission of the State, increasing the capacity of this reservoir 100,000,000 gallons.

In 1926 the 20-inch conduit from Highland Reservoir was extended the remaining 4,800 feet to the filter plant. During this same year

the National Water Main Cleaning Company received the contract to clean the Highland 12-inch main throughout its entire length.

The results of these various steps on the Highland system have been very gratifying. For instance, in 1915, before installing the first 6000 feet of 20-inch pipe from Highland Reservoir, the pressure at a hydrant located at the highest point on the system was 18 pounds and after the completion of this 6000 feet the pressure at this hydrant was 23 pounds. After completing the balance or 4,800 feet of 20-inch pipe to the filter plant the pressure at this same hydrant became 27-pounds and in 1927 after cleaning the 12-inch main from the filter plant down the pressure at this hydrant was raised to 37 pounds.

TREATMENT AND REFORESTATION

To aid filtration in the ten gravity filters sulphate of alumina is added to the unfiltered water. In the six pressure filters alum is added. We use about $\frac{1}{4}$ grain of each of these coagulants per gallon of water. No chlorine is used in the water at the present time, although the matter is under consideration. Whenever algae appears in the reservoirs they are treated with copper sulphate under the direction of the city chemist. The chemist also makes a monthly analysis of the filtered and unfiltered water.

The city owning all the drainage area around the three reservoirs, has done considerable reforestation. Plantings have been made at various times since 1912 until now there has been planted on the water shed 604,000 trees, mainly scotch and white pine and norway spruce. The cost of planting these trees was about one cent per tree and they seem to be in excellent condition.

There are no buildings on the water shed except those in which the two caretakers or watchmen live. No fishing is allowed in the reservoirs.

FINANCIAL DATA

The average daily consumption is 3,300,000 gallons.

Only 4 percent of the services are metered. These meters are read once a month and the consumer billed once a month. Flat rate consumers are billed semi-annually in advance.

The water rates are very reasonable. The average property owner pays about ten dollars a year which includes bathroom fixtures, sink, wash tubs and sprinkling privileges for the season. The meter rates average about one cent per 100 gallons.

The distribution system consists of about 52½ miles of cast iron pipe, varying in size from 4- to 24-inches. There are 350 hydrants and 417 gates in the system. Since 1926 we have adopted the policy of putting a gate on each hydrant installed. Hydrants are inspected twice a year and all gates are operated at least once a year.

Records have been kept for many years of the daily consumption and the yearly rainfall. A complete record is also kept of each meter in service.

The total outstanding debt of the Middletown water department at the present time is $295,000.00, of which $227,000.00 are sinking fund bonds due in 1930 and the balance, $68,000.00 are serial bonds due at the rate of $3,000.00 annually. Of the sinking fund bonds due there is on hand in cash and investments $168,161.65, leaving a balance of $58,838.35. This balance plus the serial bonds of $68,000.00 makes a net debt of $126,838.35.

The book value of the entire water system on April 1, 1928	$915,617.08
New debt as stated above	126,838.35
Leaving a balance or the city's equity	$788,778.73

The book value is distributed as follows:

Collecting system	$521,035.99
Distribution system	292,808.05
Filter plant	97,460.39
Office equipment and miscellaneous	4,312.65
Total present value	$915,617.08

The annual income from the sales of water is subdivided as follows:

Domestic consumers	$48,000.00
Metered consumers	10,500.00
Railroads	6,000.00
Building permits	1,500.00
Interest	2,000.00
Total annual income	$68,000.00

The cost of production is subdivided as follows:

Administration and accounting	$7,000.00
Taxes	8,000.00
Salaries of filter plant employees, watchmen at the reservoirs, chemist, foreman and cost of chemicals and other materials	16,000.00
Maintenance of mains, hydrants gates, etc	2,800.00
Total annual cost of production	$33,800.00

This amount, subtracted from the total annual income, leaves a net income of $34,200.00. From this net income must be taken the annual debt due, which consists of $9,175.66 in principal and $9,940.00 in interest, leaving a final balance of $15,084.34 for replacements and extensions.

At the present time our three reservoirs are full and we have a bountiful supply of water, nevertheless we are at present interested in the future and have for the past year been gauging the flow of water in the Shawangunk Kill above Kinch Dam, which at that point has a drainage area of about six square miles.

THE MENASHA, WISCONSIN, WATER PURIFICATION PLANT[1]

By John K. Kuester[2]

Until the year 1905 the City of Menasha was without a public water supply, but in this year it installed a Diesel engine powered pump and a distribution system composed of large cast iron water mains. Raw water was delivered from Lake Winnebago, the largest inland fresh water lake within one state. This lake covers an area of over 300 square miles and takes the drainage of several thousand square miles It is, therefore, virtually an inexhaustible supply, but the water was increasingly contaminated by heavy vegetable growths which caused it to become more undesirable for universal use, so that the use of water was materially reduced during the summer months from June to November.

Up to 1920, no treatment of any kind was given the raw water, but in that year two chlorine solution feed machines were installed, to guard against water borne diseases, although the bacterial count was remarkably low.

The pumping plant was entirely revamped in 1924, and so arranged that a water purification plant, which we knew would soon have to be built, could be conveniently connected.

Pure water was being demanded by our consumers and city-wide agitation during the past 12 years, therefore, finally convinced the city officials that a water purification plant was a most urgent necessity. Accordingly early in 1927 the funds were procured to build a 4 m.g.d. purification plant.

Ground, therefore, was broken on August 26, 1927, and the plant began full operation March 26, 1928, and has been operating successfully since. The plant is situated immediately adjacent and attached to the city's Diesel electric power and water pumping plant.

The building and other structures are of stone, brick, reinforced cement, concrete and steel, the only wood in the structures being doors and frames, windows and frames, and their trim and the

[1] Presented before the Wisconsin Section meeting, October 11, 1928.

[2] Superintendent, Water Works, Menasha, Wis.

ceiling and roof. These were of short spans and were built thus on account of the ease of insulating against loss of heat during the winter heating months. The walls of the main building, which composes the lobby, laboratory, washroom, chemical machine room, alum storage room, general stores room and operating room, as well as the front walls of the clear water storage reservoir are faced with a smooth repressed fire brick of a pleasing brown shade. The interior finish of the walls in the lobby, laboratory, washroom and operating room is face brick of a light brown color above white enamel brick wainscoting. The floors, stairs and baseboard in these rooms are terrazo.

DESCRIPTION OF PLANT

The raw lake water flows by gravity through a 24-inch cast iron pipe to the intake well which has a $\frac{5}{8}$-inch mesh screen which catches all coarse materials, if any. From this cistern the water is drawn through a twin strainer with $\frac{3}{16}$-inch mesh screens, an 18-inch pipe line which branches to two low head electric motor driven centrifugal pumps, one of which has a capacity of 1800, the other, 2800 g.p.m. These pumps deliver raw water to a 16-inch header through suitable pipe, fittings and valves either direct to the forebay or the aerator system to the two settling basins. Suitable valves for by-passing the aerator system are in this line. The water level is kept nearly constant in the settling basins, being controlled by an automatic float controlled level controller which controls a 16-inch hydraulic gate valve. Liquid chlorine and alum solutions are injected just beyond this control valve on the way to the settling basins.

The aerator system consists of 32 spray nozzles of 100 g.p.m. capacity mounted on a header and manifold system of piping, with 4 valves, so that 12 spray nozzles can be shut off during normal daily operation. All are mounted in a square concrete tank whose inside dimensions are 30 by 34 by 4 feet deep, mounted on the top and center of the two settling basins, part of the roof of which constitutes the floor of this tank.

In the pump room, which is under the laboratory and lobby, and which contains the raw water pumps and controls, and heating apparatus, is an electric motor driven centrifugal pump of 5600 g.p.m. capacity which is used as a wash water supply, taking the water from the near end of the clear well, for high velocity wash of filters, in preference to having an overhead storage wash supply. This

pump is remote controlled by push button stations at each filter operating table, when necessary to wash the filter.

The covered settling basins consist of reinforced waterproofed concrete tank 18 feet deep by 80 feet square divided in center by a wall so as to make two independent basins.

Adjacent to the ends of settling basins is the pipe gallery 10 feet wide by 80 feet long and 18 feet high, which is beneath the operating room floor and houses the filter controls and piping. In this gallery are four complete sets of hydraulic valves and venturi type rate-of-flow controllers together with the usual auxiliary piping and sample pumps all arranged in one row along the filter bed and clear well. walls. Two chlorine solution feed machines of the vacuum type are installed in the chemical machine room, one of which is normally used for prechlorination, the other for the sterilizing of the water before going to the distribution pumps. In this room also are two dry chemical feed machines, one of which is in operation continually. The machines are fed through hoppers from the upper chemical storage room, the hoppers being filled daily by the attendant. The solution from these dry feed machines is injected into the raw water pipe line on the settling basin side of the automatic basin level controlled valve. The dry chemicals are hauled from railroad siding by truck to rear of building whereupon the attendant operates a one-ton electric hoist which delivers it to the chemical storage room directly above the chemical machine room.

The operating room is 20 feet wide, 80 feet long and 12 feet high It is directly over the pipe gallery and one half of each filter unit. Directly at each filter is a control table of which there are four. On each table is an indicating rate-of-flow and loss of head gage in a single case on top of which is mounted a green shaded straight bracket type fixture, a filtered water sample pipe and stop, a push button station for wash water pump motor control and a pressure stop valve for the four-way valve control header.

The filters of which there are four in number are all in one row next to the pipe gallery and above one half of the clear water storage well. They are of one m.g.p.d. normal capacity, 16 feet by 20 feet, and contain a double header cast iron manifold with 2-inch cast iron pipe laterals drilled staggered on under side. Above this are 18 inches of graded gravel and 30 inches of sand. Above the sand in each filter are three cast iron wash troughs suspended in walls on each end and in center by hangers, the usual compartment being on near

end of trough to allow the wash waste to drain to the sewer. From the filters the water passes through the connecting piping, hydraulic controlled valves, and venturi type of rate controlling to the clear well. The clear well is 40 feet wide, 100 feet long and 8 feet deep, divided in two compartments by a concrete wall which has an opening 4 by 7 feet at the far end from No. 1 filter, through which all filtered water must pass on its way to the other half of the clear well and then to the distribution pumps. This feature was incorporated into this clear well not only to support the far end of the filters, but to keep the water moving and live so that no great amount of ice can form during winter months and to avoid water getting "dead." The only "dead" water which might accumulate being taken out by the wash water pump. The clear well has a capacity of 250,000 gallons. A feature also of interest is the automatic shutting down of the rate-of-flow controllers when the clear well is full, by the use of small tanks suspended on opposite end of weight on end of controller, filling with water from clear well thus tending to counter-balance the control weight.

The laboratory contains a complete set of such usual equipment as is needed for making proper tests to check the operation of the plant and the quality of the incoming and outgoing product.

The lobby is fully two stories high, and has a terrazo faced stairway leading up to the operating room. It is equipped in club style with reed furniture, bronze lantern type electric fixtures, clock and house plants.

Exterior windows on the sunny side walls of both lobby and laboratory are equipped with appropriate awnings.

The filter beds, clear well and settling basins can easily be extended to increase the plant capacity to 10 m.g.p.d.

The capacity of this plant may seem large compared to our population of 8500, but this city has several large industries that require a pure supply, the average work day consumption being 2 m.g.p.d. for all uses. Our rates are based on continued mass production of water close to the safe capacity of the plant.

The cost of the plant complete was $138,000.00. It was designed by the A. E. McMahon Engineering Company of this city. C. R. Meyers & Sons Co., of Oshkosh were the builders of the structures, and the Norwood Engineering Company of Florence, Mass., furnished the filter equipment. Plumbing and heating were furnished by local contractors and other incidentals were furnished by the city departments.

THE CORRELATION OF SULPHITE REDUCING AND COLON BACTERIA IN WATER

By I. M. Lewis,[1] Thomas C. Green,[2] and Viola Hamilton[3]

The bacterial reduction of sulphites in media containing a fermentable carbohydrate and metallic salts was first studied by Wilson (1921). In subsequent investigations Wilson and Blair employed a sulphite-glucose-iron agar for the quantitative estimation of the number of *B. welchii* and other reducing bacteria in water. In the first of these investigations (1924), 54 samples, including 21 shallow wells, 9 springs, 15 catchment reservoirs, 8 sand filters and one river were analyzed. It was found that sulphite reducing bacteria were absent from non-polluted supplies and the conclusion was reached that water in shallow wells and springs containing more than two reducing colonies per 10 cc. should be regarded with suspicion.

In a more extended investigation (1925), these workers examined 252 samples of water from various sources to determine the correlation of the sulphite reduction test and tests for colon bacteria. The number of dark sulphide colonies varied from none in waters of high sanitary quality to several hundred in polluted supplies. Waters from clean mountain valleys, reservoirs and clean catchment areas never contained more than 1 or 2 per 40 cc. The results show some degree of correlation between the test for *B. coli* and the reduction test. The number of sulphite reducing colonies usually varied from 5 to 320 per 40 cc. when the *B. coli* presumptive test was positive in 0.1 cc. Frequently, however, sulphite reducing organisms were not found even when the presumptive test was positive with 0.1 or 1.0 cc. In twenty such instances the coliform bacteria were found to belong to the aerogenes group.

The conclusion was reached that a definite correlation exists between colon bacteria of fecal origin and sulphite reducing bacteria in water, and that the sulphite reduction test is a valuable supple-

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[2] Bacteriologist and Chemist, City Water Plant, Austin, Texas.
[3] Instructor in Biology, College of Industrial Arts, Denton, Texas.

ment to the colon test in judging pollution of water supplies. As a standard for the interpretation of results, it was suggested that a very pure water should contain no sulphite reducers, a potable water not more than 4 and sand filtered water not more than one per 40 cc.

The purpose of the present investigation is to compare the above standard with the standard set by the U. S. Treasury Department for colon bacteria in water.

METHODS

The test for sulphite reducers was carried out according to the method of Wilson and Blair (1925). Forty cubic centimeters of water from each sample were added to an equal volume of Wilson's sulphite-glucose-iron agar and immediately poured into large petri dishes. As soon as the agar solidified, a similar quantity of agar was added. The dishes were incubated at 37°C. for a period of 24 to 36 hours and examined for the presence of dark sulphide colonies.

The test for colon bacteria was carried out in the usual manner. All positive presumptive tests were confirmed on eosine-methylene blue agar and tests to determine fecal or non-fecal origin were made by transplanting from typical colonies to peptone agar containing 1.0 percent ferric ammonium citrate as proposed by Lewis and Pittman (1927).

The samples were principally from the unchlorinated, sand filtered water of the Austin purification plant, and from the various large fissure springs which occur along the Balcones Escarpment from Austin to San Antonio. The waters from these springs have been analyzed by Lewis (1926) and by Lewis and Pittman (1928) and are known to contain colon bacteria both fecal and non-fecal in origin. The Austin city supply is drawn from the Colorado River. It is treated by the usual method of coagulation, sedimentation, rapid sand filtration and finally chlorination. The raw river water is grossly polluted at all times Analyses show that colon bacteria are usually present in 0.1 cc. and frequently in 0.01 cc. Sulphite reducers are also abundant but appear to be less variable in number.

CORRELATION OF THE TESTS

The comparison of the two standards is based on analyses of 246 samples of filtered water and 20 samples of water from fissure springs. The filtered samples may be divided into three groups. In group one,

consisting of 173 samples, colon bacteria were not present. The number of sulphite reducing bacteria is shown in table 1.

It is seen that 50 samples contained neither colon nor sulphite reducing bacteria. In 88 samples, sulphite reducing bacteria were present, but not in sufficient numbers to exceed the Wilson-Blair standard. In the remaining 35 samples, 20.3 percent of the total, the two standards fail to correlate. These samples would be classed as potable by the colon standard, but not by the standard of Wilson and Blair for sulphite reducing bacteria.

TABLE 1

The number of sulphite reducing bacteria in filtered water which contained no colon bacteria

SULPHITE REDUCERS PER 100 CC.	NUMBER OF SAMPLES	PERCENT OF TOTAL SAMPLES	QUALITY OF WATER BY WILSON BLAIR TEST
0	50	28.8	Good
1–6	47	27.2	Good
6–11	41	23.7	Good
11 and above	35	20.3	Bad

TABLE 2

Sulphite reducing bacteria absent in 40 cc. and B. coli present in 10 cc.

NUMBER OF 10 CC. PORTIONS CONTAINING B. COLI	NUMBER OF SAMPLES	PERCENT OF TOTAL	QUALITY OF WATER BASED ON COLI TEST
1	16	40	Questionable
2	11	27.5	Bad
3	7	17.5	Bad
4	2	5	Bad
5	4	10	Bad

In group two, consisting of 40 samples, colon bacteria were present in some or all of the 10 cc. portions but sulphite reducing bacteria were not present in 40 cubic centimeters. Results of the presumptive test are shown in table 2.

All of the positive tubes contained colon bacteria of fecal origin as denoted by the type of colonies which developed on eosine-methylene blue agar and by failure to deposit iron when transferred from typical colonies on this medium to citrate agar.

There is less correlation in this group than in the samples which

contained no colon bacteria. Classed by the colon standard 16 samples are questionable while 24 or 60 percent of the total are not potable.

TABLE 3

Number of sulphite reducing bacteria in water containing B. coli in each 10 cc. portion

NUMBER OF SULPHITE REDUCERS PER 100 CC.	NUMBER OF SAMPLES	PERCENT OF TOTAL	QUALITY OF WATER BY WILSON AND BLAIR TEST
1–6	8	24.2	Good
6–11	7	21.2	Good
11–26	4	12.1	Bad
26 and above	14	42.4	Bad

TABLE 4

Correlation of test for colon bacteria of fecal origin and sulphite reducing bacteric in spring water

NUMBER OF SAMPLE	POSITIVE TUBES FROM FIVE 10-CC. PORTIONS	SULPHITE REDUCERS PER 40 CC.
1	4	56
2	2	7
3	4	212
4	5	269
5	4	105
6	4	404
7	0	4
8	2	93
9	5	32
10	5	69
11	1	53
12	5	27
13	5	5
14	0	0
15	0	0
16	0	0
17	1	20
18	5	123
19	5	585
20	5	84

In group three consisting of 33 samples, colon bacteria of fecal origin were present in each of the five 10-cc. portions. The distribution of sulphite reducing bacteria is shown in table 3.

All of the samples of this group fail to pass the colon standard for potability while 15 samples 45.4 percent would be classed as potable by the Wilson-Blair standard

The results as a whole show lack of correlation in the samples of filtered water. Either of the standards alone gave a higher percentage of potability than was obtained when both were applied.

The samples of spring water gave somewhat better correlation, but there were similar discrepancies. These results are shown in table 4.

The total of 20 samples contain 6 only which are satisfactory when judged by the number of colon bacteria. Two of these contained sulphite reducers in excess of the suggested standard for potable water. The number of dark sulphide colonies varies greatly in the various samples. For example, in sample number six which contained colon bacteria in four of the five lactose broth tubes, there were 404 sulphite reducers per 40 cc. while in sample number thirteen there were but five, although all of the five 10-cc. portions contained colon bacteria.

GENERAL DISCUSSION

The dark sulphite colonies which develop on Wilson's agar when plated according to the method employed in the above analyses are probably spore forming anaerobes. Assuming that they are such, the question resolves itself into whether or not the demonstration of such organisms in water is of any great sanitary significance or of any special value as an index of fecal pollution,

The testing of water for spore forming anaerobes has been advocated by various workers in the past, but methods heretofore in use were so difficult and time-consuming that such tests have not been favored in routine practice. The test for anaerobes has also met serious objections on the basis of its value as an index of pollution. The literature dealing with this phase of the subject is so well known that further discussion could add nothing of value. The attitude of American bacteriologists has been concisely summarized by Levine (1921). On the basis of results obtained by the Wilson and Blair method, there seems no reason to recede from the position, that the test for spore bearing anaerobes in water adds little or nothing of value to the information obtained by the test for colon bacteria.

SUMMARY

The results of analysis of 246 samples of filtered and 20 samples of spring water for sulphite reducing and colon bacteria are reported.

On the basis of the standard established by the U S. Treasury Department for colon bacteria in drinking water and the standard proposed by Wilson and Blair for sulphite reducing bacteria, the tests fail to correlate.

The sulphite reduction test appears to have little or no value as a supplement to the standard test for colon bacteria.

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AN ELECTRICAL APPARATUS FOR HEATING BACTERIOLOGICAL TRANSFER NEEDLES

By Jack J. Hinman, Jr.,[1] and S. D. Poarch[2]

In the Water Laboratory Division of the Iowa State Hygienic Laboratories, at the University of Iowa, where a large number of water samples are examined and, consequently, where a large number of cultures are transferred from positive lactose broth tubes to liquid media or streaked on solid media, a type of furnace described in this article, has been perfected to increase speed by facilitating the sterilization of transferring needles. When an entire morning is regularly devoted to the transferring of cultures, a great deal of time is consumed in heating a transfer needle in a flame. Supports and fantailed burners are not very satisfactory. If the needle could be kept heated red hot and thus sterile, and ready for use at any time, considerable time could be saved, especially if the device were convenient and received the needle as easily as laying it down. A desire for such a device was responsible for the development of this furnace.

The complete unit, mounted and ready for use, is shown in figure 1. Briefly, it consists of a quartz tube wound with nichrome wire through which passes a current from an ordinary light circuit. The tube with its winding and asbestos coating is packed in a brass housing which makes the problem of mounting it an easy one. A small coil of number 22 (Brown and Sharp gauge) nichrome wire, 16 feet long, to provide a small amount of outside resistance, is connected in series with the heating winding in order that the temperature within the quartz tube may be controlled. About 12 feet of this outside resistance is connected to one terminal of a small two-way switch, and the entire length, to the second terminal which makes it possible to put all or part of the resistance in the circuit.

The quartz tube and heating coil are shown in figure 2. The tube is 8 inches long and $\frac{5}{8}$ of an inch in diameter. The open end is flared.

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[2] Superintendent, Water Works, Olean, N. Y.

The closed end is merely sealed like the end of a test tube. The winding consists of 18 to 20 feet of number 24 (Brown and Sharp

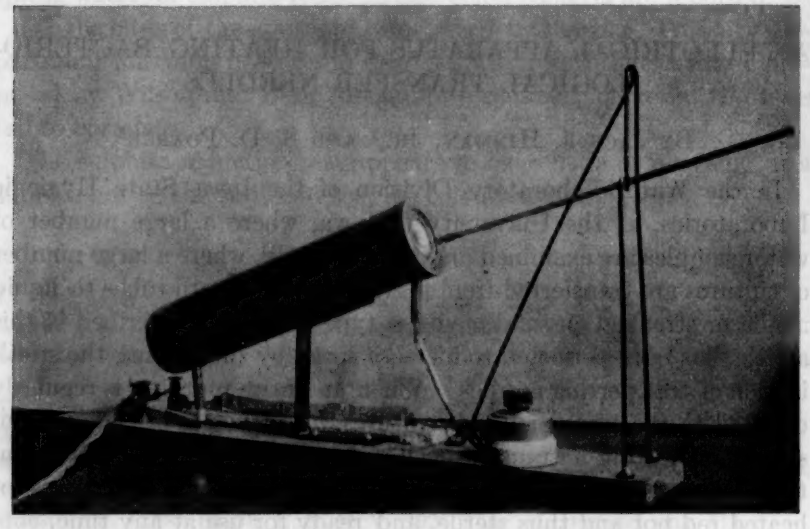

FIG. 1. FURNACE FOR HEATING NEEDLE

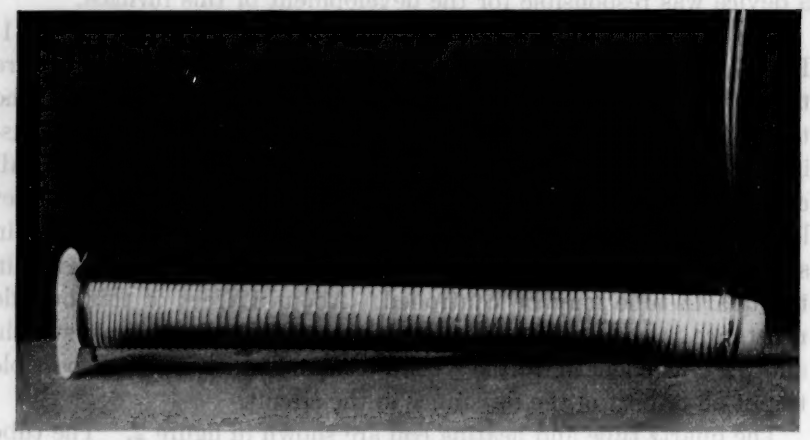

FIG. 2. QUARTZ TUBE AND HEATING COIL

gauge) nichrome wire. The ends of this winding are gold soldered to heavy nichrome leads.

The heavy leads are soldered on the winding before it is wound on

the tube. All flux must be carefully washed from the joints before the wire is wound on the quartz tube. One end of the nichrome heat-

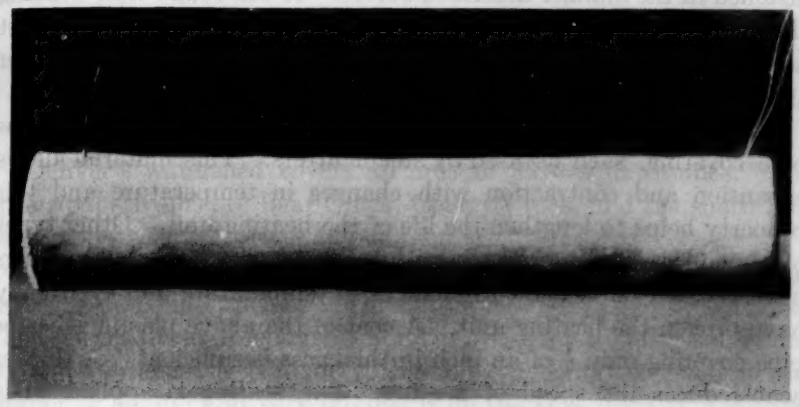

FIG. 3. FINISHED QUARTZ TUBE

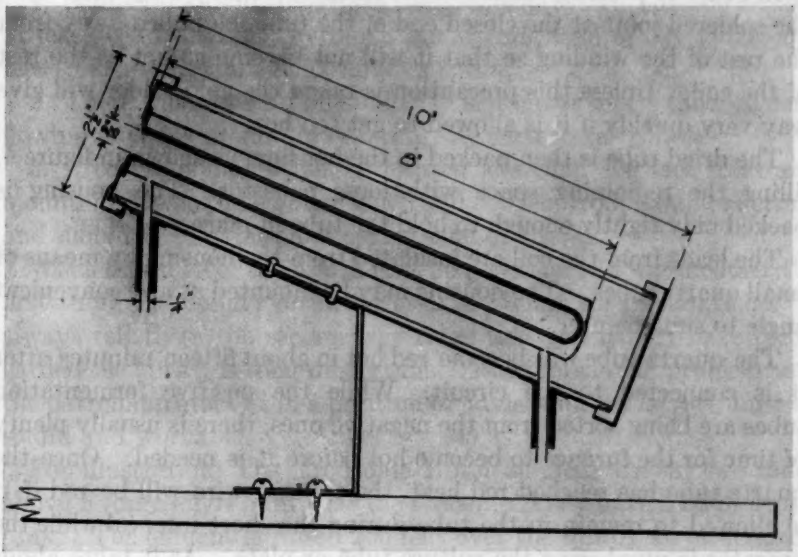

FIG. 4. DRIED TUBE IN HOUSING WITH ASBESTOS

ing element is then fastened to the quartz tube by means of two or three turns of heavy nichrome wire, the ends of which are twisted together just firmly enough to hold the winding from slipping. The

entire length of the heating coil is then wound on the tube leaving $\frac{1}{16}$ to $\frac{3}{32}$ of an inch between each turn. The end of the coil is then fastened in the manner described before. It was found that winding the heating element directly on the quartz tube was by far the most advantageous. This method of winding seemed to insure longer life of the unit.

The completed unit after winding is covered with plastic asbestos pipe covering, such as used by steam fitters. This material allows expansion and contraction with changes in temperature and this property helps to lengthen the life of the heating unit. Other types of cement have been used but with less success. The other coatings have cracked on account of changes in temperature and eventually have broken the heating unit. A coat of the above plastic asbestos pipe covering only $\frac{1}{4}$ of an inch in thickness is sufficient. A thicker coat reduces the speed of heating. The coating is applied while quite wet. It is allowed to dry, and is then baked to remove the moisture. The finished unit is shown in figure 3.

In order to prolong the life of the heating coil, it is important that the soldered joint at the closed end of the tube, be pulled away from the rest of the winding so that it will not become as hot as the rest of the coil. Unless this precaution is taken the gold solder will give way very quickly if it is allowed to get too hot.

The dried tube is then packed in the housing, as shown in figure 4, filling the remaining space with loose asbestos. The housing is packed only tightly enough to hold the tube in place.

The leads from the coil are insulated from the housing by means of small quartz tubes. The housing may be mounted at any convenient angle to suit the user.

The quartz tube will become red hot in about fifteen minutes after it is connected to the circuit. While the positive fermentation tubes are being sorted from the negative ones, there is usually plenty of time for the furnace to become hot before it is needed. Once the quartz tube has reached red heat, the transfer wire will be red if it is allowed to remain in the tube during the short interval while the operator is numbering the culture tube or plate. As it takes about thirty seconds for a transfer wire to be heated thoroughly in a flame, it will be seen that there is a saving of time as well as much greater convenience if one can have the transfer wire always hot and ready for immediate use.

PROBLEMS OF A WATER-SHED PATROLMAN[1]

By S. F. Glass[2]

Denver's watershed covers an area of 3910 square miles. The principal streams are Bear Creek, Cherry Creek, and the south fork of the South Platter River and all their tributaries.

One of the biggest problems is rural sewage disposals, as a great many of the country homes and mountain cabins are being modernized. The sewage disposal in a great number of cases is an after consideration. The house is built on a location that suits the fancy of the owner or builder and very often it is on the very brink of a stream, with no possible chance of sewage disposal. The regulations of the Colorado State Board of Health provide as follows:

1. Septic tanks and all parts of their seepage system shall be located at least 100 feet from any mountain stream, lake or dry gulch, 200 feet from a well, and 300 feet from a spring.

2. There should be no possibility of sewage or septic tank effluent flowing over the ground or entering any such water course.

3. A cesspool should not be located less than 300 feet from any mountain stream, lake or dry gulch and 500 feet from a well or spring, and should be only in soil of coarse sand or gravel.

When informed of the health laws on pollution of a water course the first thing the builder or owner asks is "What am I going to do," I always tell them the stream was there first and if they have disregarded the laws it is their misfortune. But there is the problem and the patrolman must be in a position to advise and the advice must be sound and workable.

For illustration, The Troutdale Hotel on Bear Creek, two miles above Evergreen, is built near the stream. They have a large septic tank. The effluent is raised 200 feet over the hill by an electrically driven pump, then is carried through 2000 feet of three inch pipe to a disposal field, which consists of a series of open wells. Mr. Sidels,

[1] Presented before the Rocky Mountain Section meeting, February 14, 1930.

[2] Sanitary Inspector, Board of Water Commissioners, Denver, Colo.

the president of Troutdale, has told me that it costs approximately $200.00 a month to take care of their sewage.

There are a few cases where cement water tight vaults are built and sewage pumped into tank wagons and hauled to and dumped into old mine holes, where there is no chance of it washing or getting into a stream.

Another problem is the camper in the hills and along the streams. He very seldom provides a toilet, the most essential thing about a camp, but uses the hillside and at the first rain everything is washed into the stream. As there are hundreds of campers during the summer months and frequent rains the camper becomes quite a problem.

The hardest problem to solve is to find the owner of a dead animal without a brand. If it is on deeded ground the problem solves itself. We simply notify the party who owns the ground to dispose of it But on the open range or highway it is different, and I sometimes have to dispose of it myself. Almost all cattle have a registered brand, but very few horses have and if they are branded, quite often it is a foreign brand and not registered in this state.

When we find a dead animal with a registered brand near a stream we notify the party under whose name the brand is registered, regardless of what part of the country the animal is found in or where the owner lives. It is his property and he must take care of it. We sometimes have to notify an offender the second time, but do not have to make many arrests. We are not out with the big club. Results are what we want. In eight and one half years that I have been patrolling Denver's watershed I have had to make only seven arrests.

NOTES ON THE DETERMINATION OF NITRATES*[1]

By G. W. Burke,[2] Max Levine,[2] and G. H. Nelson[2]

In the course of some work on the purification of packing house wastes, a question arose as to the proper technique for the determination of nitrates. The method employed was that recommended in Standard Methods of Water Analysis, which consisted of alkalinizing the sample, boiling down to about one-fourth volume to expel ammonia, then reducing with aluminum and determining the amount of ammonia produced by this reduction. According to Mahin[3] not only is ammonia expelled, but the nitrites are decomposed during the concentration of the alkaline solution so that the ammonia liberated by the aluminum reduction is all nitrate nitrogen. On the other hand, Sutton[4] maintains that the concentrate contains both the nitrite and nitrate nitrogen. In the latter view the nitrites would have to be subtracted from the ammonia nitrogen produced by reduction to obtain the nitrate. In the packing house wastes in question the nitrites were frequently so high (over 30 p.p.m.) that slight errors in evaluating between standards when multiplied by the extremely high dilution factors not infrequently gave higher figures for nitrite N alone than those obtained by reduction which would if the latter view is correct include both nitrites and nitrates. This would mean negative nitrates, which is evidently absurd.

Some work was therefore undertaken to determine whether the reduction method yields both nitrites and nitrates or nitrates alone, and particularly whether a method could be devised for the determination of the nitrates independently of the nitrites by the reduction method.

STABILITY OF NITRITES IN ALKALINE SOLUTION

The first series of observations was to ascertain whether the nitrites, when present alone or together with nitrates, are decomposed on

* Financed in part by grant from The Chemical Foundation.

[1] Presented before the Missouri Valley Section meeting, November 7, 1929.

[2] Engineering Experiment Station, Ames, Iowa.

[3] Quantitative Analysis, p. 428 (1924).

[4] Volumetric Analysis (Williams), p. 445.

concentration of an alkaline solution. Known quantities of nitrites and nitrates were placed in suitable containers, diluted to 100 cc. with distilled water free from nitrites or nitrates, 5.0 cc. 40 percent NaOH added, and the mixture boiled down to 25–40 cc. The concentrate was then reduced in the usual manner and the liberated ammonia determined by nesslerization. Some of the results are shown in table 1.

The data in table 1 indicate very clearly that there was no appreciable destruction of any nitrites by the process of concentration.

TABLE 1

Effect of concentration of strongly alkaline solutions containing nitrites and nitrates on determination of nitrogen by reduction method

NITROGEN PRESENT AS			NITROGEN RECOVERED BY REDUCTION
NO_2	NO_3	Total	
p.p.m.	*p.p.m.*	*p.p.m.*	
	10.0	10.0	10.0
	20.0	20.0	19.4
	10.0	10.0	10.6
10		10.0	9.7
20		20.0	19.4
10*		10.0	9.95
2*		2.0	1.94
5	5.0	10.0	9.95
10	10.0	20.0	19.4
20	10.0	30.0	30.0
40	10.0	50.0	48.8

* $Ca(NO_2)_2$, others $NaNO_2$.

In some instances, there were discrepancies between the amount of nitrogen present and that recovered. This is attributed to the high nitrogen content which introduced a large conversion factor, and, therefore, possible error as a result of slight misjudgments, and error in judging between two consecutive tubes containing standards for comparison. In view of these facts, it seems reasonable to assume that all the nitrogen originally present had been recovered.

The influence of ammonium chloride on the stability of nitrites when subjected to various modes of treatment is shown in table 2.

It is apparent that, in the presence of ammonium chloride up to over 3500 p.p.m., there was probably no destruction of nitrites by the process of concentration of a *strongly alkaline* solution or the evaporation of such a solution to dryness. On the other hand, if the nitrite solution containing this quantity of ammonium chloride was evaporated to dryness before being made alkaline, the nitrites were destroyed as may be seen from Series II samples number 21, 23, and 24.

TABLE 2

Effect of NH_4Cl on stability of nitrites

SERIES	SAMPLE NUMBER	NITROGEN PRESENT AS				NITROGEN FOUND	TREATMENT
		NO_2	NO_3	NH_3 from NH_4Cl	Total		
		p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	
I	10	10		50	10	9.4	Standard procedure: Added 5 cc. 40 per cent NaOH to 100 cc. solution; concentrated to 25 cc. reduced with Al, etc.
	19	10		1,000	10	10.0	
	11	10	10	100	20	18.8	
II	21	10		1,000	10	0.25	Evaporated solution to dryness, then added 100 cc. distilled water and 5 cc. 40 per cent NaOH concentrated and reduced as for Series I
	23	10	10	1,000	20	8.1	
	24	50	10	1,000	60	10.0	
III	33	20		1,000	20	20.0	Made solution strongly alkaline. Evaporated to dryness, then diluted and proceeded with determination as in Series I

Observations on the influence of chlorides up to 3500 p.p.m. in the presence of 1000 p.p.m. NH_3 and 500 p.p.m. organic nitrogen showed conclusively that nitrites and nitrates could be quantitatively recovered by the alkaline concentration and reduction method. The evidence is quite distinct, therefore, that nitrites are not destroyed by concentration of an alkaline solution, and that in the determination of nitrates by the standard reduction method the nitrites must be

determined independently and subtracted from the nitrogen value obtained by distillation after reduction.

ELIMINATION OF NITRITES

It is well known that under some conditions NH_3 and NO_2 decompose into free nitrogen and water even at low temperatures (about 80°C.). Neogi and Adhicary[5] prepared NH_4NO_2 by treating nitrites of sodium or potassium with NH_4Cl, Curtman and Lebowitz[6] in their work on "The detection and rough estimation of nitrates" showed in a qualitative way, that $(NH_4)_2SO_4$ could be successfully employed to eliminate nitrite nitrogen.

TABLE 3

Destruction of nitrites by evaporation in presence of ammonium chloride

NITROGEN PRESENT AS			TEST FOR NO_2	TOTAL N RECOVERED	REMARKS
NO_2	NO_3	NH_4Cl added			
p.p.m.	*p.p.m.*	*p.p.m.*		*p.p.m.*	
10		1,000	Negative		Evaporated to dryness, diluted with N free water and tested for nitrites
10		500	Negative		
10		250	Trace		
10		100	Strong		
0	4.0	1,000	Negative	4.0	Evaporated to dryness, diluted with N free water made alkaline, then concentrated and determined, nitrogen by reduction method
10	4.0	1,000	Negative	4.0	
0	7.5	1,000	Negative	7.5	
20	7.5	1,000	Negative	7.5	
0	15.0	1,000	Negative	15.0	
30	15.0	1,000	Negative	15.0	

To solutions containing 10, 20 and 30 p.p.m. of nitrites were added considerable quantities of NH_4Cl, and the mixtures evaporated to dryness on the water bath. The residue was dissolved in nitrite free water and tested for nitrites with sulphanilic acid-alpha-naphthylamine. The tests were negative showing complete destruction of nitrite.

[5] P. Neogi, and B. B. Adhicary, Mellor, Treatise in Inorganic Chemistry, vol. 8, p. 470.

[6] L. J. Curtman and S. H. Lebowitz, The Detection and Rough Estimation of Nitrates, Chem. News, 1926, **132**: 293–295.

The quantity of NH_4Cl required to destroy 10 p.p.m. nitrite (from sodium nitrite) as may be seen from table 3, was somewhat more than 250 p.p.m. It is also evident that 1000 p.p.m. NH_4Cl sufficed to destroy as much as 30 p.p.m. of nitrites and that nitrates at least up to 15 p.p.m. were not affected. This procedure may, therefore, serve as a basis for the direct determination of nitrates without making corrections for nitrites.

In short, the method consists of adding about 1000 p.p.m. NH_4Cl to the test sample and evaporating to dryness. This serves to destroy the nitrites. The residue is now taken up in about 100 cc. of nitrogen free water, 5 cc. of 40 percent NaOH, added and the

TABLE 4

Determination of nitrates in industrial wastes by the reduction method employing the standard and nitrite elimination procedure

NITROGEN PRESENT AS			NH_4Cl	NITROGEN RECOVERED	NO_3	METHOD	WASTE
NO_2	NO_3	Total					
p.p.m.	*p.p.m.*	*p.p.m.*	*grams per 100 cc.*	*p.p.m.*	*p.p.m.*		
0.95	0.93	1.88	0.1	1.0	1.0	NO_2 destruction	Raw beet pulp water
0.95	0.93	1.88		1.75	0.8	Standard	
2.38	2.33	4.71	0.1	2.46	2.46	NO_2 destruction	
2.38	2.33	4.71		4.50	2.12	Standard	
4.75	4.65	9.40	0.1	4.33	4.33	NO_2 destruction	
4.75	4.65	9.40		9.50	4.75	Standard	
	12.8	12.8	0.1	12.7	12.7	NO_2 destruction	Purified creamery waste
5.0	12.8	17.8	0.1	12.7	12.7	NO_2 destruction	

mixture boiled down to about 25 cc. This serves to expel the free ammonia. The concentrate is then reduced with aluminum and the nitrogen determined as recommended by standard methods. The nitrogen in the distillate is recorded as nitrate.

To ascertain the applicability of the method to trade wastes nitrates were determined in pulp water from a beet sugar factory and in a purified creamery waste, by the standard method and the proposed nitrite destruction method. Additional quantities of nitrites were also placed in these solutions to test out the dependability of the method. The results are shown in table 4, from which it is apparent

that the two methods were of the same degree of dependability and accuracy.

SUMMARY AND CONCLUSIONS

1. The reduction method for the determination of nitrates includes both nitrates and nitrites.

2. Nitrites were not destroyed by boiling a strongly alkaline solution even in the presence of an excess of ammonia.

3. Chlorides and organic matter apparently did not interfere with the accuracy of the standard reduction method for nitrates.

4. Nitrite nitrogen can be completely eliminated without affecting the nitrate nitrogen by evaporation of a neutral solution to dryness in the presence of an excess of ammonium chloride. This may be satisfactorily employed as a modification of the reduction method for determination of nitrates, for the purpose of eliminating the troublesome correction for nitrites.

Clemens Herschel

Died, March 1, 1930

Clemens Herschel, oldest living member of the American Society of Civil Engineers and inventor of several devices which have aided the development of hydraulic engineering, died on March 1 after a brief illness. He would have been eighty-eight years old on March 23.

Mr. Herschel was the inventor of the Venturi water meter, a simple device without working parts, for the measurement of liquids through conduits. The invention won for him the Elliott Cresson medal of the Franklin Institute of Philadelphia. Earlier in his career Mr. Herschel designed the Holyoke testing flume, which is said to have marked the start of scientific designing of modern water-power wheels.

A native of Boston, Mr. Herschel was graduated from Lawrence Scientific School at Harvard in 1860. For the next twenty years he specialized in bridge design. Turning to hydraulic engineering he became engineer for the Holyoke Water Power Company in Massachusetts, with which he remained until 1889, when he was called to develop the water supply in Newark, N. J., and vicinity. He brought the waters of the Pequahannock River into this district and his work was distinguished by the first use of steel pipe as the main tube for conveying water.

Mr. Herschel continued his work in New Jersey until 1900, after which he became a consultant for several projects. He was consulting engineer for large water supply companies at Niagara Falls and his services were sought on water supply developments throughout the world. He was on the committee appointed by Mayor John Purroy Mitchel of New York to study plans for the supply tunnel of the Catskill aqueduct.

While traveling in Italy in 1898, Mr. Herschel found in a monastery the original manuscript kept by Frontinus, designer of the Roman water supply system. His translation was published under the

title, "Frontinus and the Water Supply of the City of Rome," which has become one of the best known works dealing with hydraulic engineering. Mr. Herschel also was the author of "Continuous Revolving Drawbridges" and "One Hundred and Fifteen Experiments."

He was president of the American Society of Civil Engineers in 1916 and a member of the Institute of Civil Engineers of London, the Union Club of Boston and the Century and Engineers' Clubs of New York. He was an honorary member of the American Water Works Association.

Mr. Herschel was twice married. His first wife, Mrs. Grace Hobard Herschel, died in 1898. They had three children, Arthur H., Winslow H. and Clementine Herschel, now Mrs. Hobart Rawson. His second wife, who survives, was Jeanette B. Hunter, of Thompsonville, Conn., whom he married in 1910. They had one son, Clemens Herschel, Jr.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Coördination of Biological and Chemical Work in the Investigation of Polluted Waters. DAVID ELLIS. Ind. Chemist, 4: 291–4, 1928. From Chem. Abst., 22: 4190, November 10, 1928. Albuminoid ammonia and oxygen absorbed tests do not always show correlation with number of bacteria. Black mud is not necessarily an indication of sewage pollution. Bacteria in black mud of Clyde liberate hydrogen sulfide which forms black iron sulfide from iron compounds present. This black mud continues far beyond zone of any possible sewage contamination. *Cladothrix dichotoma* and *Crenothrix polyspora*, members of group of iron bacteria, may cause reservoir to resemble muddy, dirty pond for weeks on end. They flourish best in water from boggy or marshy ground.—*R. E. Thompson.*

Yorkshire Rivers Purification. Wool Manufacturer's Problem. ALFRED F. BARKER. J. Textile Sci., 2: 97–9, 1928. From Chem. Abst., 22: 4255, November 10, 1928. Wool-scouring industry in Yorkshire has by-product of approximately 34,000 tons of fats, 33,000 tons of soils and 11,000 tons of potash salts. These are chief constituents of river contamination, and could be avoided by having wool cleaned before shipping or at port of entry.—*R. E. Thompson.*

The Red-Lead Question. Action of Red Lead in Rust-Protecting Paints. H. WOLFF and R. SINGER. Farben-Ztg., 33: 1909–13, 1928. From Chem. Abst., 22: 4260, November 10, 1928. RAHDER'S statement (Farben-Ztg., 33: 741–3, 1927) that red lead accelerates corrosion of iron is true only for system: red lead—iron—water, and does not hold for paints in which red lead forms the pigment. Oil adsorbed by highly dispersed red lead may vary very considerably, and is of more importance in determining rust-protecting capacity of paint than is the total oil content. Protective action of the paint is due to thin, almost molecular, film in which oil is present as extraordinarily strong adsorption complex with the pigment and base.—*R. E. Thompson.*

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[1] Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

Deterioration of Concrete by Corrosive Waters. R. GRÜN. Chem. Fabr., 1928, 281–3, 294–5. From Chem. Abst., 22: 4220, November 10, 1928. Most important damage is caused by sulfuric acid, either combined, in sea water, or free, in natural acid water. Ordinary concrete can be made resistant by producing dense non-porous aggregate of uniformly sized material. At least 400 kgm. of cement per square meter must be used. Painting with bitumen is beneficial and better than covering with clinker and cement. Aluminous cement with 7 to 50 percent aluminum oxide is very resistant to magnesium sulfate, but its behaviour in presence of sodium sulfate is doubtful. Resistance of pozzuolana to corrosion is very great, as is shown by existence of water mains in good condition today which were constructed of this material by the Romans. Effect of its addition to concrete is to increase the density and to liberate lime, which acts protectively. It can only be used with slow-setting concrete. Cements prepared from blast-furnace slag fall into same class; or a mixture of blast-furnace slag and portland cement may be used. Those made from acid slags have not high initial strength, but if clinker content is low they are very resistant to salt water. Aluminous slags have best "hydraulic qualities" of any, but are not so resistant to corrosion as might be expected. Generally speaking, all these cements have less initial strength than portland cement, but greater resistance to corrosion.—*R. E. Thompson.*

The Manufacture of Submarine Paints. JUAN GARCIA. Quim. Ind., 5: 164–7, 1928. From Chem. Abst., 22: 4260, November 10, 1928. Best and most frequently used paints are: mercury oleate, linoleate, tungstate, and resinate, or, better still a combination of mercury, copper, and arsenic salts. HOLZAPFEL'S copper-mercury paint developed in 1885 is one of best.—*R. E. Thompson.*

The Scope of Corrosion-Resisting Steels in Chemical Engineering. T. H. BURNHAM. Ind. Chemist, 4: 320–4, 1928. From Chem. Abst., 22: 4446, November 20, 1928. Discussion of special corrosion-resisting steels and their applications. Steels can be obtained which are resistant to iron sulfate and filter alum.—*R. E. Thompson.*

A Simple Colorimeter for Determining Iron and Other Components in Water. F. MEINCK and MARGARETE HORN. Kl. Mitt. Ver. Wasserversorg. Abwasserbeseitig., 2: 130–5 (1926); Chem. Zentr., 1927, II, 1745. From Chem. Abst., 22: 4275, November 20, 1928. With new colorimeter 0.1 milligrams of iron, 0.1 of ammonia, and 0.5 of nitrite nitrogen per liter can be determined in 100 cc. of water.—*R. E. Thompson.*

Catalytic Action of Mineral Waters. F. C. GAISSER. Z. angew. Chem., 41: 401–7, 1928. From Chem. Abst., 22: 4333, November 20, 1928. Benzidine reaction has been investigated for number of naturally occurring waters. Those showing positive reaction invariably contain ferrous or manganous ions, or both, but converse does not hold. Explanation of these relationships. remains obscure.—*R. E. Thompson.*

Separation and Titrimetric Determination of Lime and Magnesia. R. SCHMIDT. Kl. Mitt. Ver. Wasserversorg. Abwasserbeseitig, 3: 21–3; Chem. Zentr., 1927, II, 1879. From Chem. Abst., 22: 4406, November 20, 1928. Well-known method of separating calcium and magnesium by means of Blacher's palmitate solution is described in detail.—*R. E. Thompson.*

Mottled Enamel: Report of an Examination of an Afflicted District in Italy. FREDERICK S. MCKAY. J. Dental Research, 8: 353–65, 1928: cf. C.A., 21: 2707. From Chem. Abst., 22: 4618, November 20, 1928. Conclusive evidence was obtained that water used during years of growth of enamel of the teeth is one etiological factor in occurrence of mottled enamel.—*R. E. Thompson.*

The Iodine Content of the Soil, Water, and of Some Foods in Regions Afflicted with Goiter. F. MEINCK. Kl. Mitt. Ver. Wassersorg. Abwasserbeseitig., 3: 10–1; Chem. Zentr., 1927, II, 1884. From Chem. Abst., 22: 4637, November 20, 1928. Data given for 4 communities in Taunus, Germany.—*R. E. Thompson.*

Colorimetric Iron Determination with Potassium Thiocyanate. L. S. VAN DER VLUGT. Chem. Weekblad, 25: 495–6, 1928. From Chem. Abst., 22: 4404, November 20, 1928. Presence of salts, particularly of phosphates and sulfates influences color intensity of ferric thiocyanate. More thiocyanate ions and higher acidity counteract this effect. For practical purposes at salt concentration of city water it was found that following procedure gave dependable results. In 300 cc. Erlenmeyer flask acidify 100 cc. water with 10 cc. dilute sulfuric acid (1:5) and add 3 to 4 cc. 5 percent iron-free potassium persulfate. Boil for 5 to 10 minutes; if solution is not then colorless, add more persulfate and boil again. Cool, filter, transfer to 100 cc. colorimeter glass, fill to 90 cc. and add 10 cc. 20 percent potassium thiocyanate. Immediately compare color with standards obtained by increasing quantities of ferric solution plus 4 cc. 5 percent potassium persulfate and quantities of acid and potassium thiocyanate equal to those of treated sample. Mohr's salt is recommended as standard for iron. Limit of accuracy is 0.1 p.p.m.—*R. E. Thompson.*

Metal-Metal Oxide Electrodes. F. J. WATSON. Chem. Eng. Mining Rev., 20: 172–5, 1928. From Chem. Abst., 22: 4342, November 20, 1928. Metal-metal oxide electrodes do not alter composition of solution and are well adapted for continuous recording of pH. They act well in alkaline region where quinhydrone is useless, though the pH at which hydroxide commences to be neutralized limits their use on acid side. Calibration curve for each combination has to be established by comparison with hydrogen electrode in series of buffer solutions. Application of the tungsten and platinum-manganese sequixoide electrodes in control of boiler feed water discussed.—*R. E. Thompson.*

Modern Water Softening Plant. Textile Recorder, 46: 542, 45–6, 1928. From Chem Abst., 22: 4684, November 20, 1928. Illustrated description of "Osilameter" automatic feed gear for lime and soda ash made by Paterson Engineering Co., London.—*R. E. Thompson.*

The Analysis of Chlorine Bleaching Solutions. H. SUNDER. Chimie et industrie Special No., 467–70, April, 1928. From Chem. Abst., **22**: 4407, November 20, 1928. Determination of hypochlorous acid and sodium hypochlorite is based on reactions: $HOCl + 2KI = KCl + KOH + I_2$ and $NaOCl + 2KI + H_2O = NaCl + 2\,KOH + I_2$, which were indicated by LUNGE, but have apparently not been used to date. It is carried out by adding KI and then a measured excess of 0.2 N hydrochloric acid, titrating liberated iodine with sodium thiosulfate and then the excess hydrochloric acid with sodium hydroxide. If T = cc. 0.1 N thiosulfate, t = cc. 0.2 N hydrochloric acid added, t_1 = cc. 0.2 N sodium hydroxide in the back titration, x = cc. 0.1 N hydrochloric acid required to neutralize the potassium hydroxide formed from hypochlorous acid and y = cc. 0.1 N hydrochloric acid required to neutralized the potassium hydroxide formed from sodium hypochlorite, then $x = T - 2(t - t_1)$ cc. 0.1 N HCl for hypochlorous acid and $y = 4(t - t_1) - T$ cc. 0.1 N HCl for sodium hypochlorite.—*R. E. Thompson.*

Influence of Bile and Brilliant Green on Rate of Growth of Colon Bacilli. HAROLD W. COLES and MAX LEVINE. Proc. Iowa Acad. Sci., **34**: 92, 1927. From Chem. Abst., **22**: 4562, November 20, 1928. Evaporated bile may inhibit or stimulate growth of colon bacilli depending on concentration of bile, reaction of medium, and strain or organism employed. With all samples of bile employed, a concentration of 2 percent accelerated growth whereas 5 percent was inhibitory in acid media (about pH 6), and stimulating in alkaline media (pH 7.3 to 7.8). With 2 percent dried bile, concentrations of more than 1:50,000 brilliant green distinctly retarded growth, and with 5 percent evaporated bile concentrations of 1:20,000 or less of dye were not considered inhibitory.—*R. E. Thompson.*

Calculation of the Most Economical Thickness of Insulation. E. BORSCHKE. Arch. Wärmewirt., **9**: 117–20, 1928. From Chem. Abst., **22**: 4675, November 20, 1928. Detailed mathematical discussion, with diagrams to aid in solution of equations.—*R. E. Thompson.*

Titrimetric Determination of Sulfuric Acid in Water. A. DOBROWSKY. Allgem. Z. Bierbrauerei Malzfab., **55**: 277–8; Chem. Zentr., 1927, II, 2701. From Chem. Abst., **22**: 4408, November 20, 1928. Barium chromate method of ANDREWS in form proposed by WINDISCH and LAMPE (Analyst **48**: 66, 1923) for determination of sulfuric acid was investigated thoroughly. It was found that with very low concentrations of sulfate the errors are great. Results are always too low, which may be explained by fact that barium chromate used in determination contains other soluble barium salts which also precipitate sulsulfate. Since barium salts are removed only with difficulty from barium chromate precipitate, a method for preparation of pure barium chromate is given. Chief value of preparation lies in fact that not more than one-third of quantity of barium salt neceassry for precipitation is taken and potassium chromate solution containing pure ammonia is used.—*R. E. Thompson.*

Bacterium Coli as an Alkali-Forming Organism. S. GOLIKOVA. Centr. Bakt. Parasitenk. I. Abt. Orig., **108**: 213–9, 1928; cf. Centr. Bakt. Parasitenk. I Abt. Orig., **96**: 95, 1925. From Chem. Abst., **22**: 4569, November 20, 1928. White islands sometimes appear on Endo plates which have been reddened by *B. coli* in presence of mixed flora as when feces have been cultured. Possible explanation is presence of an alkali proenzyme which becomes active under influence of alkali. This enzyme produces volatile alkali; hence phenomenon may occur at distance as well as by continuity. Decolorized areas do not regain color when products of alkali formers are removed from atmosphere. Areas induced at distance can induce secondary white areas. Phenomenon is not dependent on living cultures.—*R. E. Thompson.*

Destruction of Concrete by Active Carbonic Acid. KARL BIEHL. Zement, **17**: 1102–5, 1928. From Chem. Abst., **22**: 4755, November 20, 1928. Attack of concrete by certain waters is due to active carbon dioxide present. The pH determination gives the most definite information regarding corrosive properties of water.—*R. E. Thompson.*

The Phenomena of Corrosion of Iron and Steel. A. HERRERO and M. DE ZUBIRIA. J. Iron Steel Inst. (advance copy), No. 3, 16 pp., September, 1928. From Chem. Abst., **22**: 4445, November 20, 1928. Electrolytic and chemical theories of corrosion discussed. Causes of corrosion are of 2 types: first, those which are independent of object which suffers corrosion, and second, those which are function of physical and chemical properties of object. In first classification are included: (1) Atmospheric conditions in general, (2) degree of contamination of air or water by gases, such as carbon dioxide which is very easily dissociated, or sulfur dioxide which has very intensive corrosive action, (3) stray currents from electric circuits of high potential, (4) contact with other metals or with ferrous metals of different chemical composition, (5) faulty design. In second group are mentioned; (1) local differences of composition due to non-metallic inclusions, (2) deposits, local or otherwise, of foreign bodies, (3) segregation of metalloids, (4) internal stress or strain. Also in Foundry Trade J., **39**: 239–40, 265–6, 1928.—*R. E. Thompson.*

The Protective Action of Sodium Sulfate on the Attack of Ingot Iron by Alkalies and Salts Under High Pressure. E. BERL and F. VON TAACK. Arch. Wärmewirt., **9**: 165–9, 1928. From Chem. Abst., **22**: 4445, November 20, 1928. Tests were made on powdered ingot iron in bomb at 260–360°. Up to about 0.02 N, sodium hydroxide decreases corrosion of pure water; above this, corrosion increases rapidly. When sodium sulfate is added in any amount from 0.01 to 0.9 molecule per liter, corrosion for any concentration of sodium hydroxide remains below that for pure water. Sodium chloride is weakly corrosive, and does not affect action of sodium hydroxide. Sodium nitrate evolves nitric oxide instead of hydrogen and is moderately corrosive, but inhibits sodium hydroxide to some extent. Disodium phosphate is more corrosive and a better inhibitor. Sodium sulfide is very corrosive. Röntgen spectra show that the only oxides formed are ferrous oxide and magnetite. Effect of sulfate is perhaps due to formation of firm oxide film.—*R. E. Thompson.*

Oxidation of Iron in Water by the Action of Oxygen and Carbon Dioxide. N. M. GAVRILOV, S. K. MEL, and P. K. MEL. J. Chem. Ind. (Moscow), 5: 697–700, 1928. From Chem. Abst., 22: 4447, November 20, 1928. Mechanism of corrosion is believed to be as follows: (1) Surface of iron being mechanically or chemically freed of oxides, metal becomes immediately covered by film of lower oxide on contact with air in presence of water. (2) Oxidation proceeds, with formation of ferric hydroxide. (3) Adhering film of ferric hydroxide is gradually reduced by adjacent iron with simultaneous oxidation of latter. (4) By action of water saturated with carbon dioxide on metallic iron the following reactions occur: (*a*) rapid solution of low oxides which are on surface of metal, and (*b*) slow solution of iron by carbon dioxide. (5) Ferrous bicarbonate, which dissolves, is oxidized by oxygen to ferric hydroxide, this reaction being favored by decrease of partial oxygen pressure and by temperature increase. (6) After remaining for a long time submerged in solution of ferrous bicarbonate and being subjected to action of the gas, iron becomes quasi-passive, but vigorous shaking detaches film of oxides and activity of metal is restored. (7) If gases with high oxygen content (5 percent) are blown on to iron covered with water, metal surface becomes covered with insoluble oxides while experiment is still under way, and concentration of iron in solution is decreased.—*R. E. Thompson.*

Chlorine Gas Poisoning and the Process of Becoming Accustomed to Chlorine. G. LUTZ. Zentr. Gewerbehyg. Unfallverhüt., 14: 175–6; Chem. Zentr., 1927, II, 716–7. From Chem. Abst., 22: 4640, November 20, 1928. At first breathing, chlorine gas has the ordinary well-known irritant effects, which are rendered less pronounced by use of coffee. Following this stage, there is apparent tendency to become accustomed to gas with cessation of coughing, but without diminution of other injurious effects, such as vasomoter (albuminuria) effects. Caffeine is to be used in combating these effects.—*R. E. Thompson.*

Corroding Action of Solutions of Various Chlorides on Cast Iron and Lead. B. K. PERSHKE and G. I. CHUFAROV. J. Chem. Ind. (Moscow), 5: 523–8, 1928. From Chem. Abst., 22: 4446, November 20, 1928. Results are given of experiments on action of aqueous solutions of potassium, magnesium, and sodium chlorides, saturated and dilute, pure and mixed, on cast iron. Sodium chloride solutions have maximum, and magnesium chloride minimum, corroding effect, potassium chloride being intermediate. Dilute solutions are generally more corrosive than saturated solutions, maximum corrosion having been attained with solutions of about 1 percent strength. Stirring and saturation with air treble extent of attack. Periodical drying of specimens increases corrosion 1.25 times, and light increases it 1.7 times. Rate of corrosion remains unchanged with time. Cast iron is affected to depth of 0.5 mm. annually under most unfavorable conditions. Tar coating reduced cast iron corrosion to one-fifth. Lead is attacked by solutions of chlorides one-ninth as much as cast iron, losing layer of about 0.0065 mm. annually.—*R. E. Thompson.*

The Corrosive Effect of Water and Its Deacidification. HERMANN MANZ. Wärme, 50: 401–4, 416–9; Chem. Zentr., 1927, II, 1382. From Chem. Abstr., 22: 4445, November 20, 1928. In continuation of his first article (ibid., 50: 384–8, 1927), author points out that excess carbon dioxide ("corrosive carbon dioxide"), estimated by analysis, is unimportant if its quantity does not exceed 3.3 percent of bicarbonate carbon dioxide or 11 percent of free carbon dioxide.—*R. E. Thompson.*

The Determination of the Residue on Evaporation and of Its Loss on Ignition. HORN. Kl. Mitt. Ver Wasserversorg. Abwässerbeseitig., 3: 313–4; Chem. Zentr., 1927, II, 2334. From Chem. Abst., 22: 4680, November 20, 1928. Detailed description of determination of residue on evaporation and loss on ignition.—*R. E. Thompson.*

The Determination of Hardness (of Water). Habrich. Kl. Mitt. Ver. Wasserversorg. Abwässerbeseitig., 2: 39–40, 1926; Chem. Zentr., 1927, II, 1745. From Chem. Abst., 22: 4680, November 20, 1928. Description of BLACHER'S method of (cf. C.A., 7: 1394).—*R. E. Thompson.*

Gas Production from Commercial Peptones by *Bacillus Aërogenes* and *Bacillus Coli*. E. LEE TREECE. J. Inf. Dis., 42: 495–500, 1928. From Chem. Abst., 22: 4566, November 20, 1928. Gas was produced from 2 of the 4 commercial peptones tested by *B. aërogenes* and *B. coli*, both in liquid medium under vaseline and in peptone medium solidified with agar or gelatin. Gases produced were collected, measured, and analysed. Gas ratio (carbon dioxide hydrogen) for *B. aërogenes* averaged 8.5, varying from 5.7 to 12.8. Ratio for *B. coli* was infinitely higher. The value could not be determined since the amount of hydrogen produced was too small to be measured and analysed. Source of gas seems not to be in carbohydrate radicals of the peptone.—*R. E. Thompson.*

The Influence of Anions and Cations on the Viability of *Bacillus Coli*. C. H. BOISSEVAIN and ERIC WEBB. J. Lab. Clin. Med., 13: 1027–35, 1928. From Chem. Abst., 22: 4573, November 20, 1928. Optimum concentration for viability of *B. coli* is M/4 in case of non-electrolytes and M/8 in case of binary electrolytes. H-ion concentration in phosphate solutions is of small importance as long as it remains above pH 5 and below pH 8. Cations are without effect on viability, except for valency effect. Series of increasing toxicity for anions is hydrogen phosphate, nitrate, chloride, sulfate, and iodide. Their effect is purely additive; no evidence was found of "balancing" toxicity of one ion by that of another. Hydrogen phosphate ion is only mineral constituent necessary for life of colon bacillus. Part of toxicity of distilled water and salt solutions may be due to fact that they permit diffusion of the hydrogen phosphate ion out of the bacteria. Number of colon bacilli remains constant in solution containing mixture of mono- and disodium phosphate of pH 7. The number of bacilli increases if traces of organic material are present in solution, e.g., cotton fibres or dead bacilli.—*R. E. Thompson.*

The Relative Toxicity of Gentian Violet for Certain Members of the Colon Group of Organisms. W. D. STOVALL, M. STARR NICHOLS and VERA VINCENT. J. Lab. Clin. Med., 13: 1036–40, 1928. From Chem. Abst., 22: 4573, November 20, 1928. Gentian violet has marked inhibitory effect on growth of *B. coli* in dilution of 1:20,000, preventing growth in 90 per cent of methyl red, and 50 per cent of Voges-Proskauer, cultures used in tests. Inhibitory effect was evident in methyl red-positive cultures in dilution as high as 1:75,000 while it appeared not to affect the Voges-Proskauer-positive group until a very much lower dilution (1:30,000) was reached. Inhibitory action is noticed in higher dilutions by lag produced in growth of cultures. This lag is evident in methyl red-positive cultures in much higher dilutions than in Voges-Proskauer-positive cultures. Within same groups there is variation in sensitiveness of organisms to action of the dye.—*R. E. Thompson.*

The Preparation and Testing of Food Gelatin for the Bacteriological Investigation of Water as Furnished to the Outside by the Landesanstalt für Wasser-, Boden-, und Luft-hygiene. HANS BEGER. Kl. Mitt. Ver. Wasserversorg. Abwässerbeseitig., 3: 162–75; Chem. Zentr., 1927, II, 1789. From Chem. Abst., 22: 4571, November 20, 1928. Minute description of properties of raw materials and methods of preparing and testing food gelatin.—*R. E. Thompson.*

The Detection, Determination, and Importance of Free Chlorine and of Hypochlorites in Water. H. KLUT. Kl. Mitt. Ver. Wasserversorg. Abwässerbeseitig., 3: 184–91; Chem. Zentr., 1927, II, 1879. From Chem. Abst., 22: 4681, November 20, 1928. Detection of chlorine and hypochlorites by potassium iodide-starch, *o*-tolidine, and dimethyl-*p*-phenyl-enediamine and their determination with *o*-tolidine and benzidine are described. Importance of chlorine treatment of drinking water discussed.—*R. E. Thompson.*

Accurate Observations on Some Uncommonly Protracted Lead Poisonings. A. SITZ. Münch. med. Wochschr., 74: 1364–5; Chem. Zentr., 1927, II, 1732. From Chem. Abst., 22: 4655, November 20, 1928. Clinical report on lead poisoning of 6 persons by drinking water containing lead. Beginning of poisoning lies more than 15 years back. In 1920, drinking water of certain building contained 8 milligrama and at later date 36 milligrams of lead per liter. Notwithstanding fact that pipes giving off the lead were changed, the water still contained 2.6 to 2.9 p.p.m. of lead in 1927. All symptoms of lead poisoning were present with exception of characteristic blue line on gums. In one case tuberculosis brought forth a renewal of lead poisoning symptoms which had disappeared. Symptoms were then those of acute lead poisoning with articular pains followed by paralysis of radial nerve, evidence of persistence of lead deposits in body, and their slow excretion. Administration of iodine brought relief, though not recovery because of long existence of the disease.—*R. E. Thompson.*

Determination of Moisture in Steam by Electrical Conductivity. M. E. FITZE. Power, 68: 484–5, 1928. From Chem. Abst., 22: 4674, November 20, 1928. It is assumed that entrained moisture in steam carries solids in same proportion as in boiler water. Calibration curve is obtained by collecting 2

liters of condensate, adding boiler water in increments of 2 cc., and determining conductivity with Leeds and Northrup portable resistance meter, using a portable dip cell. Conductivity is plotted against percentage boiler water added. Second curve, drawn through origin and parallel to first shows direct relation between moisture of steam and conductivity of condensate.—*R. E. Thompson.*

Mixing Solids with Liquids Such as in Water Purification. WILSON EVANS (to National Aluminate Corp.). U. S. 1,686,076, October 2. From Chem. Abst., **22**: 4678, November 20, 1928. Continuous stream of finely divided solids is projected at high velocity against surface of water. Apparatus described.—*R. E. Thompson.*

The Determination of Carbon Dioxide. ECKERLIN. Kl. Mitt. Ver. Wasserversorg. Abwässerbeseitig., **2**: 40–3, 1926; Chem. Zentr., 1927, II, 1745. From Chem. Abst., **22**: 4680, November 20, 1928. Methods used in water analysis for determination of total, bicarbonate, free and active carbon dioxide described.—*R. E. Thompson.*

Determination of Chlorides. HORN. Kl. Mitt.Ver. Wasserversorg.Abwässerbeseitig., **2**: 257–8, 1926; Chem. Zentr., 1927, II, 1746. From Chem. Abst. 22, 4680, November 20, 1928. Discussion of MOHR method, with modifications necessary with colored waters and waste waters.—*R. E. Thompson.*

The Gravimetric and the Volumetric Determination of Lime in Water. R. SCHMIDT. Kl. Mitt. Ver. Wasserversorg. Abwässereseitig., **2**: 242–7, 1926; Chem. Zentr., 1927, II, 1745. From Chem. Abst., **22**: 4681, November 20, 1928. Description of gravimetric and volumetric oxalate methods. Latter has important advantages over former.—*R. E. Thompson.*

Destruction of Bacteria by Ammonia and Chlorine. W. OLSZEWSKI. Chem.-Ztg., **51**: 269–70, 1927; cf. C.A., **20**: 2713. From Chem. Abst., **22**: 4682, November 20, 1928. Results described of treatment of swimming pool with chlorine and ammonia in ratio of 2 to 1 by weight. Effectiveness probably due to formation of chloramine. Method is superior to chlorination as no odor is perceptible, water remains clearer and careful regulation of amount of chemicals added is not required.—*R. E. Thompson.*

Example of the Reactivity of Siliceous Algae to the Salt Content of Water. KONRAD GEMEINHARDT. Kl. Mitt. Ver. Wasserversorg. Abwässerbeseitig., **1**: 60–1; Chem. Zentr., 1927, II, 1744. From Chem. Abst., **22**: 4682, November 20, 1928. Fresh water diatom *Synedra ulna* is especially sensitive to high salt content of water, whereas *Synedra pulchella* is inhibited by lowering the salt concentration.—*R. E. Thompson.*

Denver Water Conduit Extension. Jos. C. COYLE. Public Works, **60**: 9, 361–2, September 1929. Gives methods used in laying 8 miles of 60-inch reinforced concrete water supply pipe. Sections were 12 feet long and weighed 7 tons each. A Northwest pull shovel was used for excavating and a 25-ton steam crane for the laying and backfilling. The Platte River was crossed by building a cofferdam in three sets. A trench 7 feet deep blasted in the bed rock

received a 2-inch cushion of fine sand before laying of the pipe. Railroad tracks were crossed by ditching under concrete culverts. At this point six inches of concrete protected the conduit from possible erosion by future floods.—*C. C. Ruchhoft.*

Breaking up Mud Holes in a Filter. A. L. Gosnell. Water Works and Sewerage, **76**: 375, 1929. A "home made" implement is described which can effectively be used in breaking up mud holes in filters.—*C. C. Ruchhoft.*

Utilizing Creek Underflow at Prescott, Arizona. Anon. Public Works, **60**: 309, 1929. To supplement the reservoir supply in emergencies, Prescott, Arizona, has found the method of underflow supply successful. On the bed rock of a creek a 72-inch corrugated pipe, 50 foot long and perforated with half-inch holes on five-inch centers, was laid. The pumping station was built at the end of the pipe at the bank. The pipe was extended to the center of the creek, bulkheaded, and three lines of 6-inch drain tile continued across the creek. The backfill over the tile and collecting pipe was made of graded rock on which was placed gravel to the level of the creek bed. The pump house contains a 100-h.p. motor connected to a 600-g.p.m. centrifugal pump on the upper floor and a 300-g.p.m. centrifugal pump connected to a motor on the lower floor.—*C. C. Ruchhoft.*

Re-sanding the Cincinnati Filters. Clarence Bahlman. Water Works and Sewerage, **76**: 10, 456, October 1929. The sand filters, which have served for 21 years, consisted originally of 8 inches of graded gravel and 30 inches of sand with a uniformity coefficient of 1.60. The size of the sand was found to increase with age, but the efficiency was not lessened. The gravel layer is still in good condition and only part of the old sand will be removed. The reconstructed filter bed will consist of the present 14 inches of gravel and a 28-inch layer of sand. Twelve to 16 inches of the sand bed will consist of new sand. Ohio River sand will be used because it is cheaper and has proved satisfactory in the old sand beds. The sand will be screened and dried; 3800 tons will be used.—*C. C. Ruchhoft* (*Courtesy Chem. Abst*).

The Reduction of Urban Typhoid. Jas. A. Tobey. Public Works, **60**: 356-7, 1929. Mortality due to typhoid in U. S. has been reduced from 20.58 per 100,000 (general average of 74 cities) in 1910 to a general average of 1.89 per 100,000 for 81 cities in 1928. Factors responsible include general sanitation, sewage disposal, milk pasteurization, control of other foodstuffs and shellfish, supervision of carriers, immunization, and, particularly, the improvement of water supplies. The most striking example of the effect of this last named factor is the figure concerning Pittsburgh, Pa. After the installation of a water filtration plant the death rate in 1910 of 65 per 100,000 was reduced in two years to 12.7. Data arranged geographically always show the best results for New England states and the poorest results for the Southern states. Total reduction has resulted in saving in one year 6200 lives in a population of 33,000,000 in various cities throughout the United States.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Developing a Surface Water Supply. ARTHUR L. REEDER. Public Works, 60: 220–3, 1929. Changes in industrial conditions, standards of living, metering and water rates, paving, and water pressure must be considered to determine future quantity requirements. Fluctuations in precipitation and run-off must be determined and allowances made for the maximum and minimum conditions in developing a surface water supply.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*)

Parkersburg's New Water Supply. M. G. MANSFIELD and F. C. FOOTE. Public Works, 60: 270–1, 1929. The new supply is taken from 9 drilled wells, from 51 to 61 feet in depth, located in a row extending about 3200 feet along the Ohio River bank and about 15 to 25 feet from its top. The wells discharge into a pipe leading to the CO_2 removal plant, which includes aërator with spray nozzles, mixing tank, clear water reservoir, and pump room. Pumping tests showed that the wells, including the three old wells, would yield a supply of 6 m.g.d. in dry weather.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Tunneling for Hetch-Hetchy Water Supply. CHARLES W. GEIGER. Public Works, 60: 232–4, 1929. This project includes 84.9 miles of tunnels which are divided into four main divisions. The first two of these divisions, known as the Mountain Division and the Foothill Division, are now completed. The work described is on the Coast Range Division where the general method has been to drive a section about 10 by 10 feet with vertical walls, an arch of 5 feet radius and a bottom radius of about 15 feet. Where the rock conditions permitted, the tunnel was enlarged somewhat and left unlined. Where lining was necessary the section was not enlarged. Two shafts over 800 feet deep were required. Large volumes of water were encountered. The equipment used on the work is described.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Some 1928 Water Works Data. Anon. Public Works, 60: 244–7, 1929. Data compiled from questionnaires show the amounts and kinds of pipe laid as street mains and the principal features of water treatment in the cities reporting.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Mixing and Coagulation in Water Works Practice. M. P. HATCHER. Water Works and Sewerage, 76: 10, 435, October, 1929. The term *mixing* means only the action necessary to mix the chemicals, the coagulant, and the water. *Coagulation* is the process by which the flocculent precipitate coalesces into larger and more rapidly settling particles. *Retention period* is the time required for the water to pass through the mixing unit as determined by its displacement. *Velocity* is the average velocity of the water in the cross section normal to the axis of flow. The devices used in mixing and coagulation are baffled basins, tanks with paddles for agitation, and the hydraulic jump. Complete coagulation comprises two steps: (1) chemical reaction between coagulants and treated water; (2) physical change, involving aggregation of the flocculent precipitate.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Improving Water System of Scotia, New York. HENRY W. TAYLOR. Public Works, **60**: 9, 358–61, September, 1929. The initial water supply equipment, consisting of six 8-inch tubular wells connected by means of a long suction header, became inadequate as the population of the city increased. Tests indicated the need of greater infiltration area and of increased storage facilities. The proposed change includes the following units: (1) new open well, 10 by 15 feet in area and 30 feet deep below the level of the pump room; (2) three vertical-shaft rotary pumps of 400-, 600-, and 800-g.p.m. capacities which will discharge into low level reservoir; (3) high duty pumps, to include two single stage centrifugal pumps of 2,000 gallons capacity and one of 600 gallons.—*C. C. Ruchhoft.*

The New Water Supply of Charleston, S. C. J. E. GIBSON. Water Works and Sewerage, **76**: 10, 413, October, 1929. To furnish an additional supply of water during droughts the water department of Charleston constructed a conduit from the Edisto River to the Ashley. The conduit, which is below the hydraulic grade between the two sources, was excavated through marl formation for a distance of 4½ miles and provides an increase of 5 m.g.d. at a construction cost of $383,000.—*C. C. Ruchhoft.*

The Importance of Control of Raw Water. A. L. GOSNELL. Water Works and Sewerage, **76**: 10, 444, October, 1929. The water reservoir of Laurel, Md., a lake of 7,000,000 gallons, was treated with lime to eliminate algae. Lime was spread around the circumference of the lake and a bag of lime anchored in the stream 100 feet above the inlet to the lake. Improvement in the water was noticed within a few days and less alum was needed in the treatment at the plant. Increased oxygen content, however, caused the filters to become air-bound after a 3-hour run. Improvement in the raw water overcame this objection.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Sand and Gravel Requirements for Filters. Anon. Water Works and Sewerage, **76**: 10, 434, October, 1929. Fine sands are more efficient than coarse in the removal of bacteria and give more uniform action over the filtering area. The cost of cleaning finer sand is more, because clogging occurs more readily. The grading of sand must be controlled by the factors "effective size," and "uniformity coefficient" and it must contain at least 90 percent silica. Gravel, which serves as a base for filter sand, must be graded carefully and be of high silica content.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Artesian Water Supply of Memphis, Tenn. ANON. Water Works and Sewerage, **76**: 10, 415, October, 1929. The United States Geological survey has issued a report on the artesian water development and the geological region of Memphis, Tenn. The total pumpage from artesian wells is about 38 m.g.d., the water being soft and low in mineral content.—*C. C. Ruchhoft.*

The Importance of Salts in Drinking Water. B. REWALD. Mineralwasser-Fabrikant, **33**: 177, 242, September, 1929; Chem. Zbl., **1**: 22, 2678, 1929. A water, to be regarded as suitable for drinking, must contain a certain minimum

of CaO and MgO. The most satisfactory ratio of CaO to MgO is 7:1. In districts where the water is poor in lime, a specially compounded mineral water may be added.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

pH Value of Distilled Water. C. VAN DER HOEVEN. Collegium, 1928, 440; Brit. Chem. Abst., November, A. 1203, 1928. A colorimetric estimation, using a dilute solution of methyl red neutralised with sodium hydroxide, is the most accurate method. The quinhydrone electrode method gives an error on the acid side, diminishing in proportion to the amount of buffering.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Arsenic in the Waters of East Prussia. G. and W. RUDOLPH. Z. angew. Chem., 40: 945, 1927. Wass. u. Abwass., 24: 174, 1928. A general survey is given of the occurrence of arsenic in nature. The authors determined the arsenic content in the water and sludge of the Frisch harbour near Königsberg at varying distances from the point of discharge of waste waters from a cellulose factory. The results are tabulated. The Baltic sea water between Pillau and Kolberg contains 1 to 2 parts of arsenic per 1000 millions. The water in the "Fischhaus" creek of the Frisch harbour, at a distance of about 6 km. from the cellulose factory sewer, contains from 5 to 10 parts per 1000 millions, while smaller quantities were found in the water near Narmemn at a distance of 30 km. Of the two rivers flowing into the harbour, the water of the Pregel contains 2.5 to 3 parts of arsenic per 1000 millions, and that of the Passarge, 2 to 4 parts. The water in the Kurisch harbour contains 1.5 to 3, and in the rivers Deine and Gilge, 1.1 to 3 parts of arsenic per 1000 millions. The presence of arsenic in the rivers of East Prussia is most probably derived from natural sources and not due to pollution from factories. The sludge contains greater quantities of arsenic than the water above it, showing that arsenic probably passes from the water to the sludge. The sludge in the Frisch harbour contains between 5.1 and 30 p.p.m. of arsenic in the dried sludge, and that in rivers, 2.1 to 6.3 p.p.m. Similar quantities are found in the sludge from the Kurisch harbour and its rivers. It is concluded that the presence of greater quantities of arsenic in the sludge as compared with the water in these rivers and harbours is due to the action of bacteria and microscopic organisms, which absorb the arsenic from the water and on dying sink to the bottom, thus enriching the sludge in arsenic. This is confirmed by the fact that the sludge richest in humus matter is also richest in arsenic.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Simplified Electrodes for the Measurement of pH. L. KÖHLER. Chem. Ztg., 53: 69, 1929. Wass. u. Abwass., 25: 302, 1929. There are three principal methods for the electrometric determination of pH, using the following combinations of electrodes: a quinhydrone electrode against a relative quin-

hydrone electrode; a quinhydrone electrode against a saturated solution of calomel electrode; and a hydrogen electrode against a calomel electrode. Dr. TÖDT has combined the last two methods and produced a new type of electrode. The connection between the electrodes is made with a solution of potassium chloride, to overcome the high resistance of which, which would alter the resulting measurements, TÖDT uses a diaphragm of average permeability. The electrode, in the shape of a U-tube, has the calomel electrode on one side and the hydrogen or quinhyrone electrode of the solution to be tested on the other. A connection is formed by the potassium chloride solution passing through the diaphragm to the calomel electrode. A microelectrode was constructed on the same principle.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

The Titrimetric Determinations of Carbon Dioxide. L. SMITH and G. WODE. Z. angew, Chem., **41**: 208, 1928, Wass. u. Abwass., **24**: 266, 1928. The various methods of determining carbon dioxide are compared: (1) titration with phenolphthalein by the method either of SEYLER-TRILLICH or of TILLMANS-HEUBLEIN; (2) titration with methyl orange by LUNGE or KUÖLER; (3) determination of the total carbon dioxide in vacuum by WESTERBERG; (4) addition of baryta and sugar by PETTENKOFER-TRILLICH-WINKLER-WESTERBERG. The author considers that the titration method by TILLMANS and HEUBLEIN in which phenolphthalein is added until a persistent rose colour is obtained, gives unsatisfactory results. If a solution of a definite pH value, (a SÖRENSEN buffer mixture of 3.7 cc. of hydrochloric acid and 6.3 cc. of borate, pH = 8.4) and 0.3 cc. of a 1 percent phenolphthalein solution are used with 100 cc. of water, good values, with an average error of only 4 percent, will be obtained even with the high concentrations of carbonic acid and bicarbonate usually present in natural waters. In the determination by precipitation of the carbonate with excess baryta and barium chloride and back-titration with acid, sugar being added before precipitation, by WESTERBERG, it was noticed that the precipitation of the magnesium hydroxide was retarded by the sugar and that the precipitated carbonate crystallised immediately. It is best to leave the mixture for fifteen minutes between the precipitation and the sugar-titration, and even under these conditions the values were persistently a little too high, e.g. 8.01 millimols of CO_2 instead of 8.00.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

The Determination of Ammonia. K. TAÜFEL and C. WAGNER. Z. angew. Chem., **41**: 285, 1928, Wass. u. Abwass., **24**: 266, 1928. The authors discuss the displacement process by O. FOLIN, with air, and mention a method worked out on the principle of this process by H. DÜNWALD. Distillation of ammonia with excess magnesium oxide is discussed. Experiments by W. PREISS have shown that distillation by this method only leads to accurate results when the liquid investigated is approximately neutral.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Leptospiras from Tap Water. J. E. WALKER. Journ. Infect. Dis., 41: 164, 1927, Revue d'Hygiène, 51: 388, 1929. The drinking water of Washington, like that of London, contains a leptospira which is not pathogenic to guinea pigs. This saprophyte, as opposed to the pathogenic leptospira, develops readily on a medium composed of yolk of egg and gelatine.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

The Composition of Water and Mosquito Breeding. W. RUDOLFS and J. B. LACKEY. Amer. J. Hyg., 9: 160, 1929. Chem. Abst. U. S., 23: 1974, 1929. Studies were made of the relation between the composition of water and the abundance of mosquito breeding. Larvae are killed within 24 hours when the pH of the water changes rapidly, while a gradual change in reaction does not affect the death rate. External conditions also affect the breeding; a low pH may be favourable under certain conditions and a high pH under others. The number of microscopic animals and plants affects the amount of breeding. Tables and graphs illustrate the various points studied.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

The Control of Drinking Water Supplies. F. SCHÜTZ. Ges. f. öffentl. Gesundheitspflege, Sitzung October, 1927; Zbl. f. d. ges. Hyg. u. ihre Grenzgebiete, 16: 334; 1927, Wass. u. Abwass., 24: 233, 1928. Chlorine is now in common use in Germany for disinfecting drinking water. The determination of free chlorine in water is important in controlling the process of chlorination. The author describes a new method for the determination, using α-naphtoflavone, first recommended by BARGER, which gives a blue colour with free chlorine and changes to a light rose colour when the chlorine combines. The author has invented a small apparatus for making the determination, which can be obtained from the firm Bartsch, Quilitz, u. Co., Berlin. The α-naphtoflavone is sold by the firm Kahlbaum, A. G., Berlin, under the name of "Chlortest Kahlbaum."—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Chlorinating Liquids. Wallace and Tiernan Co. E. P. 307, 473. Pat. Off. J., 1929. No. 2102, 1761. An apparatus is figured and described for chlorinating water or sewage at a controlled rate. Chlorine gas is passed at a certain rate from a tank of liquid chlorine under pressure to an aspirator, through which the liquid to be treated or an auxiliary flow of water is passed. The chlorine passes through a pipe with control valves, a metering device, and a suction chamber to the aspirator. The different parts of the apparatus are described in detail.—*M. H. Coblentz (Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature).*

Removal of Oxygen from Water. C. TAUBERT. Z. d. Ver. Deutsch. Ingen., 71: 1272, 1927. Wass. u. Abwass., 24: 271, 1928. The "Rostex" filter constructed by the firm of Chr. Hülsmeyer, Düsseldorf, for removing oxygen from boiler feed waters is described. The oxygen is decreased to 0.5 mg. per litre by filtration of the water through the manganese "glass-wool" filter. Since installing the filter, there has been no corrosion in the boiler plant.—*M. H. Coblentz* (*Courtesy of the Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature*).

Experiments in Application of Alum in Coagulation. C. H. BURDICK. Water Works Eng., 82: 23, 1629, November 6, 1929. Modern practice indicates that a rapid initial mix followed by a slower mix for a longer period improves coagulation. Laboratory tests showed that the weaker the solution of alum the better the coagulation. Dry feed application was most consistently the best. A number of tables are included which give the results obtained. The author concludes: (1) that alum solutions should be stirred instantly on being added to the water; (2) that the effect of stagnation is lessened as the amount of alum required decreases; (3) that 20 to 30 seconds of stagnation is usually sufficient to produce poor coagulation.—*Lewis V. Carpenter.*

Is the Water Works Liable for Damages Due to Defective Fire Hydrants? LEO T. PARKER. Water Works Eng., 82: 23, 1599, November 6, 1929. Owner of a building sued a water company for damages when the water pressure was insufficient to put out the fire. Court ruled that while the city paid fire hydrant rental the contract with respect to extinguishing fires was a city contract and the water company should not assume liability to protect property owners against fire loss. In another case where the water company had a contract to keep hydrants in repair and failed to do so the court ruled that the company was not responsible. In several cases where the fire hydrants were also used for other purposes, the courts ruled against the water company.—*Lewis V. Carpenter.*

Various Methods for the Removal of Tastes and Odors. LOUIS B. HARRISON. Water Works Eng., 82: 23, 1621, November 6, 1929. Organic tastes caused by flora and fauna, trades wastes, or sewage, may be classified chiefly as chlorophenol or musty. Tests at Bay City, Mich., indicate that turbidity and color increase when tastes appear. Superchlorination was a failure here, which the writer attributes to the high organic content of the water. Laboratory experiments proved conclusively that NH_3 cannot be used to remove chlorophenol tastes, but its value as a preventer of chlorinous odors was established. Laboratory data indicate that permanganate applied before chlorination will destroy the tastes. Author thinks the permanganate-chlorine treatment to be the most successful for chlorophenol wastes met with at the Bay City plant. Activated carbon has not been used long enough to demonstrate its characteristics, but shows much promise.—*Lewis V. Carpenter.*

The Quality and the Method and Results of Treatment of the Portsmouth, England, Water Supply. ERNEST V. SUCKLING. Water and Water Eng., 31: 368, 349–356, August 20, 1929. The company supplying water to Portsmouth dates back to 1857 when the daily supply was 500,000 gallons from a well and a few springs. Now 10,000,000 gallons of water are taken from large springs at Havant and Bedhampton with daily average yield of about 20 m.g., so that a large reserve of water is available. Chemically, this water contains "no objectionable matter or excess of saline constituents." The results of the usual physical and chemical tests fall within narrow limits. Routine check is made weekly of electrical conductivity. Criteria for bacterial examination are (1) total bacteria and (2) presence and approximate numbers of those of excremental origin. As standard of quality, author believes that this water should contain not more per cc. than (*a*) 100 bacteria capable of growing at 20°C., or (*b*) 25 at 37°C., and that *B. coli* should be absent in 100 cc. The water coming from the springs does not meet this standard. Rainfall causes slight variations in the chemical and physical quality, but greater in bacterial, because the springs are in chalk formation. The slow sand filters have no unusual features. They are cleaned from 6–12 times per year, sand washers being of open hopper type. The filter effluent closely approaches the desired standard. To avoid plant enlargements, pre-chlorination was adopted. This has produced a uniformly satisfactory water, more than meeting the standard set, and kept down growths in the filters. When the water is at its best, chlorine dosage is 0.1 p.p.m. During 1927 the dose exceeded 0.2 p.p.m. on only 40 days. Tests for free chlorine are made daily. No disadvantage has resulted from chlorination. The questions of taste and odor were considered and plans for dechlorinating and detasting prepared. However, they have never been needed. The decline of enteric fever since 1910, when filtration started, was rapid and since chlorination began in 1926 a further drop is shown by the curve reproduced in the article.—*Arthur P. Miller.*

Stream Flows, Storm Water Overflows, and Separating Weirs. W. S. JACKSON. Water and Water Eng., 31: 368, 357–59, August 20, 1929. A short discussion of the value of procuring data on stream flows is followed by a statement of the six methods principally employed, namely, (1) cross section and floats; (2) cross section and current meters, or pitot tubes; (3) cross section and surface slope; (4) measurement over existing weirs; (5) temporary dams and rectangular weirs, or V notches; and (6) chemical means. Reasons for gauging sewage flows are given and a few ways by which this can be done described. A properly designed storm water overflow should separate excess storm water not requiring treatment and prevent fouling of streams with sewage by means of some kind of dip plate. A patented device for separating the excess above 3 times dry weather flow from the latter is described. It is not yet, however, entirely free from defects.—*Arthur P. Miller.*

The Desirability of River Gaugings for Various Purposes. E. A. SANDFORD FAWCETT. Water and Water Eng., 31: 368, 359–362, August 20, 1929. Two appendixes to the Eighth Report of the Royal Commission on Sewage Disposal are given, the first detailing the methods of gauging rivers and streams

and the second describing the gauging work of committees and commissions previous to the date of the Report. [Just what that date is, is not made clear.—ABSTRACTOR.]—*Arthur P. Miller.*

New Designs of Borehole Pumps. The Sulzer Types. Anon. Water and Water Eng., 31: 368, 362–364, August 20, 1929. This article brings out the limitations of Sulzer borehole pumps and points to certain details requiring consideration when installing such. For the shafts of these pumps, lignum vitae bearings, eliminating oil contamination of the water, are usual. In presence of sand, a special protective device can be provided. Two of these pumps have been ordered by a municipality in Poland, each to deliver 1650 gallons per minute against a head of 1066 feet. They are 10-stage pumps with shafts 584 feet long. The borehole is only 28 inches in diameter and the pump, 24 inches.—*Arthur P. Miller.*

The Electroflo Station Type Water Meter. Anon. Water and Water Eng., 31: 368, 373–374, August 20, 1929. The new Electroflo station type water meter is claimed to be the first in which the multiplying factor has been abolished. It is calibrated directly in gallons per hour. The 12-inch chart is driven by a synchronous motor clock lasting for 1200 hours. A 24-hour period is presented to view. Continuous totalization of quantity is provided.—*Arthur P. Miller.*

New Pumping Station for the Mid-Kent Water Company. Anon. Water and Water Eng., 31: 369, 397–399, September 20, 1929. The Mid-Kent Water Company is a rural undertaking supplying water to 106 parishes in Kent (England) and, in bulk, to two other companies. The population supplied is about 120,000. Nearly 500 miles of mains are in use. Thinly populated country and low rateable values on rural property enforce upon this company rigid economy when considering extensions. Diesel engines of air-injection type were selected because of their reliability and low working costs. The new pumping station discussed is at Trosley, where water obtained from borings lined with tubes is raised against a head of 207 feet by two 10-inch five-stage borehole pumps. In addition, there are four surface pumps; one 7-inch five-stage, one 6-inch seven-stage, and two 6-inch four-stage. The borehole pumps deliver the water to a reservoir where it passes over weirs to remove the sand; the surface pumps take their supply from this reservoir and deliver it to two distant distributing reservoirs. Detailed descriptions of the engines, borehole pumps, and surface pumps are given. Four months operation had proven this equipment to be quite successful.—*Arthur P. Miller.*

Rights to Underground Water. W. VAUX GRAHAM. Water and Water Eng., 31: 369, 400–404, September 20, 1929. English law recognizes no property in water until it is actually captured, nor does it recognize the right of any land owner to be assured of the use of water percolating or standing under or on the surface of his land, as against those who may drain it away or prevent its coming by operations elsewhere. A case cited exemplifies the trouble which arises; namely, that some specific operation may disturb underground water conditions to such an extent as to inflict injury on persons who had relied for

their supplies on the pre-existing state of affairs. On the other hand, the American doctrine is "that the right of a land owner with regard to the water under his land is to be use it reasonably for purposes connected with the use of his land, but not to sell, or transport it to the detriment of another land owner" A number of court rulings are cited following the exposition of this doctrine. The use of underground water for a public supply involves the effect of the necessary operation upon land owners as well as the effect of the operation of other land owners upon those who are trying to supply the public. In England, parliamentary proceedings since 1911 endeavor to protect the land owners who may be affected by pumping operations in the supply of public water in three ways: (1) imposing upon those supplying the public with water an obligation to compensate for injury within a certain area; (2) imposing certain conditions upon new public wells, either as to their working, or their construction; (3) setting down a neutral area between two operations, with the understanding that neither shall abstract water on the other's side of the line. A number of examples in which these forms of protection were used in England are cited. Additional acts along the same lines as heretofore explained, but put into effect since 1911, are given and their protective provisions set forth. The writers then discuss the general problem of the allocation and conservation of water resources and the action of the Board of Trade in recommending through its Water Power Resources Committee that a water commission be set up by the government. Although this was not done, an advisory committee was established by the Ministry of Health in 1923 to study the question of a national water policy. The various reports of this advisory committee are touched upon briefly.—*Arthur P. Miller.*

Water Storage in South Africa. ANON. Water and Water Eng., 31: 369, 404, September 20, 1929. In a paper on the utilization of available water supplies in South Africa, the writer describes the relation of rainfall to agriculture. The country naturally divides itself into winter and summer rainfall zones and agriculture in the former can survive under much smaller annual rainfall than in the latter. Where rainfall is insufficient, irrigation is resorted to; but even that is limited by rainfall and by low run-off, about 6½ percent of total rainfall. Large storage works are necessary and because of the nature of the country they are costly. An economic problem of much importance is the efficient utilization of that portion of the rainfall which does not reach the rivers and water courses (93½ percent). This may be, at least partially, accomplished by improving the methods of dry land farming. Underground water for drinking could be obtained by means of wells and bore holes, but little artesian water has been developed. In South West Africa, underground dikes have been used with success in obtaining water from the beds of intermittent streams.—*Arthur P. Miller.*

"Peebles" Combination Gauge. ANON. Water and Water Eng., 31: 369, 404–406, September 20, 1929. By means of this device a series of filter beds can be properly regulated and the total work to be performed by each proportioned. It also indicates when a filter needs cleaning by showing an increased head for any given discharge. It is compact in design, sturdily constructed,

and simple in operation. It can be applied to any existing filter outlet with a minimum of alteration. A complete description of the gauge, with two cuts and a picture, is given.—*Arthur P. Miller.*

The Rand Water Board. ANON. Water and Water Eng., 31: 369, 409–411, September 20, 1929. Report of this Board for year ending March 31, 1929, gives figures concerning cost of water and other financial matters. In the East Rand area installation of additional pipe lines has increased pressure and quantity of water available at Leeuwpoort. The second unit of the Vaal River scheme, providing a second five million gallons a day, was completed. Improvements made in the various pumping stations are touched upon. Water available for consumers aggregated 20.5 million gallons per day during the year; unavoidable leakage and wastage was estimated at 2 percent. The water quality has been consistently good.—*Arthur P. Miller.*

The Enumeration of the Anaërobic Sulphite Reducing Bacteria and the Significance of their Presence in Water. B. A. ADAMS. Water and Water Eng., 31: 369, 412–415, September 20, 1929. The writer in a very able discussion of this subject concludes (1) that anaërobic sulphite reducing bacteria, both obligatory and facultative, are numerous in feces of man, less numerous in excreta of the horse and cow, and of varying extent in that of gulls; (2) that, in feces, sulphite reducers are more numerous in the vegetative state than as spores; (3) that presence of these organisms in water indicates objectionable contamination; and (4) that preponderance of vegetative forms shows such contamination to be recent. Vegetative forms of sulphite reducers were found to be more resistant to unnatural conditions, including the presence of chlorine, than *B. coli*. There is now no certainty that all sulphite reducers are non-pathogenic and, since they are likely to be of objectionable origin, their presence in drinking water is to be deprecated.—*Arthur P. Miller.*

The Measurement of the Discharge of the Nile through the Sluices of the Aswan Dam. H. E. HURST and D. A. F. WATT. Water and Water Eng., 31: 369, 417–420, September 20, 1929. This report marks the conclusion of a work of much importance to Egypt which has been going on for 20 years. Its object was to establish an automatic and accurate measure of the discharge of the Nile throughout the year. It included 250 experiments with a large tank, 730 with current meters in the sluices, 2500 with models, and 1130 measurements of the discharge by ordinary method. The methods used are discussed and of the results obtained, the more important are considered to be, (1) the establishment of an automatic measurement of the Nile by means of the sluices; (2) the proof that current meters are reliable instruments; and, (3) the establishment of the relation between the discharge of a model and that of its prototype.—*Arthur P. Miller.*

Extremes of Rainfall Over the British Isles. JOHN GLASSPOOLE. Water and Water Eng., 31: 369, 421–424, September 20, 1929. The object of this paper, which deals with extreme values, is to furnish some indication of the rainfall statistics available at the meterological office (England). The writer discusses both dry and wet periods, correlating rainfall and the lack thereof with particular times and time intervals.—*Arthur P. Miller.*

Aërial Surveys. FREDERICK N. FOWLER. Boston Soc. Civil Engineers, 16: 9, 469–474, November, 1929. Aërial surveys can be used in the preliminary study of a watershed. Map does not have to be extremely accurate. Such survey maps will show reasonable limits of the watershed area, sections wooded and under cultivation, character of soil, location of streams, etc. By using stereoscope, topography can be studied for probable sites of dams and reservoirs. KARL R. KENNISON. Ibid., 475–477, Metropolitan District Water Supply Commission contracted for two aërial surveys. The first contract was for about 100 square miles. Contact prints were furnished with a scale of approximately 1 inch equals 1200 feet. The flying height varied from two to two and one-half miles. Enlargements were made to a scale of 1 inch equals 400 feet. The second contract was a strip to show four rivers having a combined length of 56 miles. The scale was 1 inch equals 800 feet. The enlargement scale was 1 inch equals 200 feet. When the water was high, or the surface frozen, no photographs were taken. The negatives were 7 by 9 inches and the overlap at least 50 percent. N. LEROY HAMMOND. Ibid., 478–480. Aërial surveys for the Metropolitan District Water Supply Commission were used for different purposes. Real estate maps were made of three towns by use of the contact prints. Every indication of a property line on a print was pantoraphed to a skeleton map of the town. In the field the owners' names were inserted. Contact prints aided in the analysis of real estate deeds. They were also used in checking plots of surveys of topographical features and real estate. **Aërial Survey Specifications.** CHARLES M. SPOFFORD. Ibid., 483–487.—*J. F. Pierce.*

Water Supply from Rainfall on Valley Floors. A. L. SONDEREGGER. Proc. Am. Soc. Civ. Eng., 55: 5, 1139–65, May, 1929. The rainfall on the valley floors is of great economic importance in the semi-arid regions. The penetration is affected by the character and topography of the ground, the use made of the soil, and the intensity of the storms. The author presents an analysis of the phenomenon of rainfall penetration and a discussion of methods for quantitative determination of the resultant water supply. Penetration of water into the soil in three regions of California was determined by soil moisture tests, by comparison with mountain run-off, and by test wells.—*John R. Baylis.*

Sixth Report on the Working of the Water Analysis Laboratory, Corporation of Madras, India, for the year 1927. S. V. GANAPATI. 36 pp. (1928). Extensive tabulated analytical data on the Madras water supply are given and discussed. Prechlorination was practised throughout the year, the bleaching powder solution being applied at the entrance to the raw water conduit during a portion of the year to remove algae growths. The Cl_2 dosage varied from 1 to 2.5 and averaged 1.4 p.p.m. The chlorinated raw water was of uniformly good quality, showing lactose fermenters in less than 20 cc. only on very few occasions, but as in previous years the slow sand filter effluent at times was of very much poorer bacteriological quality than the applied water. Prechlorination reduced cleaning of the filters 21 percent over the previous year and slightly increased the effective life of the filters. The number of samples from the distribution system which would be classed as good showed an increase from 8.5

in 1926 to 17.8 in 1927, the remainder of the samples failing to conform to accepted standards of purity. The atypical vibrios described previously (cf. this Journal 19,468) were isolated from time to time from both raw and treated water. Cholera broke out in epidemic form during the period July to October. Owing to failure of the west monsoon the use of water had to be severely restricted and a number of wells were brought into use, $Ca(OCl)_2$ being supplied for treating the same. A Government committee has been appointed to study the supply.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Flood Flows in Southwestern Kansas in November, 1928. J. B. SPIEGEL. Eng. News-Rec., **102**: 877–9, May 30, 1929. Details given of flood flows in Osage, Neosho, Verdigris, and Walnut River basins as result of 36-hour rain storm which occurred in eastern section of Kansas commencing on November 15, 1928. Rainfall was unofficially reported to have been as high as 14 inches.—*R. E. Thompson.*

Setting Temperatures in Concrete Bridge Piers. A. A. JAKKULA. Eng. News-Rec., **102**: 913–4, 1929. Temperature of atmosphere, of area surrounding the concrete which was enclosed with tarpaulins and heated by salamanders, and of the concrete itself during setting of piers of Cedar Ave. bridge, Minneapolis, Minn., constructed in winter, are shown graphically. A rise of 30 to 50°F. can be expected in large masses of concrete if suitably protected. Canvas and salamander protection is satisfactory.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Deep Trench Emergency Intake for Pittsburgh Water Works. Ross M. RIEGEL. Eng. News-Rec., **102**: 638–40, April 18, 1929. Discovery of dangerous conditions in concrete-lined conduit, 8 to 10 feet in diameter and 250 feet long, from river to Ross pumping station of Pittsburgh necessitated construction of second conduit. Later examination showed concrete to be disintegrating and although since repaired its life appears limited. A sheeted trench was constructed from station to river through which water could be drawn in case of emergency and new conduit was constructed in this trench. Conduit structure decided upon was a twin tunnel, either unit of which can be isolated for inspection and repair by stop logs. Conduit was provided with copper seal strips at construction joints and has proved to be very tight. Somewhat over $375,000 has been expended on the work, which has now been completed.—*R. E. Thompson.*

Drainage Channels Closely Spaced Under Concrete Lining of Reservoir. Eng. News-Rec., **102**: 687, April 25, 1929. In construction of North End reservoir at Tacoma, Wash., the concrete lining was laid in slabs 25 feet square and drainage channels were placed under most of joints, thus providing adequate escape for seepage to prevent settlement and opening of joints. Copper water stops and asphaltic filler were used in joints. All drainage galleries discharge into two 8-inch collecting pipes at center of reservoir, the water being conveyed under embankment to washout chamber. Division of lining into slabs and provision of light reinforcement is expected to prevent shrinkage cracks.—*R. E. Thompson.*

Zeolite Water Softening Plant at Mangum, Okla., Uses Open Basins instead of Pressure Tanks. H. B. CRANE. Eng. News-Rec., 102: 900–3, 1929. The hardness of the water supply of Mangum, derived from 5 dug wells about 40 feet deep, increased with the amount of water drawn from the wells and a softening plant was recently installed. Investigation indicated that zeolite softening would be more economical than lime-soda or lime-zeolite treatment. The plant is of 1-m.g. capacity and consists of raw and treated water reservoirs and softening beds. The water passes upward through 12 inches of graded gravel and 66 inches of zeolite contained in open concrete basins, unsoftened water being automatically added to the effluent to give a water of 3 grains hardness per gallon. Operating cycle consists of five and one-half hours softening and one-half hour regeneration, 4 percent salt solution being used for latter, distributed through same headers and laterals as the raw water. The cost of the softening plant was approximately $45,500. The hardness of the well water is 30 grains per gallon.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

A Year's Work in Arbitrating St. Francis Damage Claims. Eng. News-Rec., 102: 880, May 30, 1929. Total of 2828 damage claims of all kinds were filed. About 200 of these have been disallowed by committee appointed to settle the claims and of remainder about 90 percent, representing $3,431,072 in all, have been approved for payment. Many of largest claims are included in those not yet arbitrated and it is estimated that $7,000,000 may be needed to settle all outstanding claims. This is in addition to $2,000,000 expended by city of Los Angeles on restoration in Santa Clara Valley immediately after disaster.—*R. E. Thompson.*

Underwater Lighting of Swimming Pools. E. W. BEGGS. Eng. News-Rec., 102: 782, May 16, 1929. Brief discussion with several illustrations. For good lighting, approximately 30 generated lumens per square foot of surface should be maintained.—*R. E. Thompson.*

Control of Washing at Rapid Water Filtration Plants. EDWARD S. HOPKINS. Eng. News-Rec., 102: 841, 1929. Graphical data on filter washing at Baltimore, Md., show that, using a constant filtration rate (125 m.g.d. per acre), with the applied water properly coagulated and having a turbidity of 4–7 p.p.m., the length of filter runs increased as the turbidity of the final wash water decreased, becoming constant for a final wash water turbidity of 75 p.p.m. The velocity of washing has considerable influence, a final turbidity of 800 p.p.m. with velocity of 2.9 feet vertical rise per minute giving a longer filter run than 400 p.p.m. with a velocity of 2.3 feet. At Baltimore, the time required to obtain a final wash water turbidity of 75 p.p.m. varies from 6 minutes at a velocity of 2.3 feet vertical rise per minute to 4 minutes at velocities of 2.7 and 2.9 feet per minute. A 4-minute wash at 2.7 feet is therefore the most economical. Observations on filters washed by 7 experienced operators on basis of casual inspection of the wash water showed the final turbidity to vary from 25 to 150 p.p.m.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Co-operation versus Competition for International Water. C. H. PEASE. Eng. News-Rec., 102: 828–30, May 23, 1929. Historical review and discussion of situation with regard to water on Mexican border, particularly with regard to Rio Grande River. A joint commission has been set up by Governments of United States and Mexico with authority to investigate international rights in 3 river systems, Rio Grande, Colorado, and Tia Juana, and formulate basis for diversion of waters.—*R. E. Thompson.*

Excavating New Million-Yard Channel for Chicago River. Eng. News-Rec., 102: 717–9, May 2, 1929. Description of work under way on construction of new channel for Chicago River south of Loop district, excavation being carried out by dredging. New channel will be 4700 feet long, 200 feet wide, and 26 feet deep.—*R. E. Thompson.*

The Principles of Concrete Making. F. R. MCMILLAN. **I. Cement paste the basis of concrete quality.** Eng. News-Rec., 102: 580–3, 1929. **II. Strength and Watertightness: Supporting Data.** Ibid., 625–32. **III. Combining Aggregates with Paste to Make Workable Concrete.** Ibid., 673–9. **IV. Application to Specific Conditions.** Ibid., 705–9. **V. Importance of proper construction methods.** Ibid., 748–52. An exceptionally complete presentation of the fundamental principles of concrete-making theory and practice, and of the various factors affecting the quality of the product, with an abundance of supporting experimental data, for details of which the original must be consulted. The application of the principles enunciated to the production of concrete to meet specific requirements of strength, durability, watertightness, etc., is discussed at length.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Method for Forecasting Seasonal Streamflow. JOHN F. PARTRIDGE. Eng. News-Rec., 102: 752–3, May 9, 1929. Data given on activities of California-Oregon Power Co. in measuring precipitation and runoff and forecasting flow from Klamath basin. Forecasts are based on relationship between runoff and precipitation, established as accurately as possible from available records. Records covering period of years show "trend of wetness," or variation from normal.—*R. E. Thompson.*

Suspension Bridge of 170-Foot Span Meets Water Main Emergency. T. W. ESPY. Eng. News-Rec., 102: 861–2, May 30, 1929. Description of construction of 170-foot suspension bridge to which the support of a 36-inch steel pipe line conveying a large part of San Francisco's water supply was transferred from timber trestle, when a highway cut caused renewed subsidence in an old landslide.—*R. E. Thompson.*

A Farewell Word on the Venturi Meter. CLEMENS HERSCHEL. Eng. News-Rec., 102: 636–7, 1929. A brief discussion by the inventor of this minimum-loss-of-head meter which has been unapproached for precision of measurement since developed over 40 years ago. The practice of shortening the meter tube by increasing the cone angle of the discharge tube destroys one of the greatest advantages of the instrument, namely, that of regaining the head in full.

The long taper of the discharge tube also delivers the water with less turbulence and produces a more perfect "differential." Venturi tube forms can be built of wood or concrete (with exception of throat piece) inside standard pipe or penstock sections. Such meters have given reliable service for years.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Legally Safe for New York to Divert Delaware River. Eng. News-Rec., 102: 680–1, April 25, 1929. Assurance that City of New York has legal right to take floodwaters of certain tributaries of Delaware River wholly within State of New York for additional water supply is given in opinions by CHAS. E. HUGHES and JOHN W. DAVIS. Project provides for supply averaging 600 m.g.d. from floodwaters of 5 tributaries of Delaware and 100 m.g.d. from Rondout Creek, a tributary of the Hudson, with necessary impounding reservoirs and aqueducts, at estimated cost of $273,000,000. Two attempts to effect allocation of waters in question by means of tri-state compact have failed after agreement among commissions created by each state for purpose, New York Legislature alone ratifying the compact. Terms of second compact, in which attempt was made to meet objections to first one, have been followed by the engineers of the board in making plans for the diversion. It is held that plan would insure and increase the low-water flow of the river. Details of the legal opinions are given.—*R. E. Thompson.*

Determining Free Moisture in Sand. H. C. MCCALL. Eng. News-Rec., 102: 804, 1929. A simple, rapid method is described, the accuracy of which is within the limits necessary. The amount of sand which will balance a given weight, i.e., 1000 g., when submerged, is dried, weighed, and the weight of absorbed water determined. The sum of these weights is a constant. The amount of free water present in any other sample is the weight in air necessary to balance 1000 g. when submerged, less the above constant.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Design of 11,000,000-Yard Earth Dam for Saluda River Power Project. ARTHUR R. WILLWOOD. Eng. News-Rec., 102: 669–72, April 25, 1929. Details given of Saluda dam, 208 feet high, 7838 feet long on crest, and 1150 feet wide (maximum), which will be world's largest high earth dam. Structure, cost of which is estimated at $22,000,000, is being built by General Gas & Electric Corporation for its subsidiary, the Lexington Water Power Co., of Columbia. Lake Murray, as storage reservoir will be known, will be 40 miles long and 14 miles wide at widest point. Area covered will be 78 square miles and capacity will be 2,300,000 acre-feet.—*R. E. Thompson.*

Oxygen Torch Used on Difficult Under-Water Works. CHARLES KANDEL. Eng. News-Rec., 102: 633, April 18, 1929. Description of under-water work involved in replacing old steel trash rack at a Southern hydro-electric plant of the Aluminum Company of America on which almost every known tool for under-water use was employed. Temperature of water was as low as 32°F. and depth ranged from 25 to 70 feet. Steel was cut with oxygen torch, approximately 50 individual cuts being made, varying from 8 to 36 inches in length

and ½ to 2 inches in thickness. Cuts totaled 65 linear feet, actual cutting time being about 9 hours. Sixty $1\frac{3}{16}$-inch holes 5 inches deep were drilled with pneumatic hammer for attaching forms for new concrete work. During pouring, a diver, with aid of pneumatic hammer and submarine light, calked each crevice in forms with oakum as leaks appeared. Special nozzle was used for dredging in spots inaccessible to clamshell bucket.—*R. E. Thompson.*

Improved Field Equipment for the Determination of pH. E. Hurwitz and L. S. Kraus. Eng. News-Rec., 102: 704, 1929. An extemely compact comparator for determining pH in the field, employing Clark's indicators and buffer solutions, has been developed. A complete set of color standards for the pH range 1.8 to 9.2, with indicators and all equipment necessary, is contained in a case 9 by 6 by 8½ inches. The standards are sealed in Pyrex glass tubes about 11 cm. long with bore of approximately 4 mm. and capacity of 1 cc., mounted on chalk-white celluloid cards. The determination is made by pipetting 1 cc. of the unknown solution into a depression in a spot plate, adding 1 drop of indicator, mixing thoroughly, drawing liquid back into the pipet (which is made of same tubing as the standards) and comparing with the standards.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Design and Construction of High Arch Dam for Waterville Hydro-Electric Development. Eng. News-Rec., 102: 894–8, June 6, 1929. Detailed, illustrated description of construction of high thin-section arch dam for Carolinas Power and Light Co. on an almost inaccessible site in Great Smoky Mountain of North Carolina. Project as whole is located on Big Pigeon River and consists of dam, power house, and 14-foot pressure tunnel 6.2 miles long. Latter will be described in subsequent article. Dam is designed to give free drop of 180 feet to overflow, which is controlled by taintor gates. At center, dam rises 200 feet from foundations to top of taintor gate piers, spillway elevation being almost 20 feet lower. Thickness of center section varies from 40½ at bottom to 16 feet at neck, flaring out to approximately 22 feet at crest. Radius at downstream side of crest is 301 feet, except for abutments.—*R. E. Thompson.*

The First of the Mississippi Floodways. W. W. DeBerard. Eng. News-Rec., 102: 816–22, May 23, 1929. Data on an discussion of by-pass channel known as the New Madrid floodway which is about to be constructed, with estimate of degree of protection which it will afford Cairo, Ill.—*R. E. Thompson.*

An Estimate of Tower Machines for Mississippi Levee Construction. W. L. Thompson. Eng. News-Rec., 102: 682–3, April 25, 1929. **Discussion.** Writer believes that work should be done by contract as far a spossible, advantages being lower cost, better quality, and more rapid completion, or some of these.—*R. E. Thompson.*

Relative Values of Public Utility Systems. C. F. Lambert. Eng. News-Rec., 102: 634–6, April 18, 1929. Relative costs of 5 classes of public utilities are charted and tabulated, bringing up to January 1, 1929, the values which

have been recorded periodically in Engineering News-Record. Values are based on 25 water works, electric light, and artificial gas systems, 10 street railway systems, and 11 natural gas systems. Tabulations and graphs show values by years from 1913 to 1928.—*R. E. Thompson.*

Repair of Breaks in Outlet Tunnel of Rock-Fill Dam. FRED H. TIBBETTS. Eng. News-Rec., 102: 904–6, June 6, 1929. Excessive leakage developed suddenly last summer in outlet tunnel of North Bowman dam when stored water for first time attained depth of 145 feet. Dam is rockfill structure completed in 1927 which stores water for Nevada Irrigation District in Nevada County, California. Leakage was temporarily stopped with small wooden blocks pumped into tunnel and when reservoir was empty in fall the tunnel was unwatered and several breaks found in lining beyond downstream toe of dam. The breaks and methods of repairing same are described and discussed. Holes were found at 3 points where reinforcing steel was placed 6 inches on centres and thickness of concrete was about 9 inches. In each case a rock pocket, such as would be caused by overbreak, was found behind ruptured lining. Breaks may have been due to cracking or loosening of granite through which tunnel passes by the dumping of rocks up to 10 to 15 tons in weight over 40 to 50-foot bank during construction of dam after tunnel had been completed. Lining was repaired with gunite and grouting was carried out from surface above tunnel.—*R. E. Thompson.*

Solving Oil Field Waste Disposal Problems. Eng. News-Rec., 102: 795–8, May 16, 1929. Illustrated description of oil waste reclamation plant of Santa Fe Springs Waste Water Disposal Co., a non-profit, co-operative organization formed by 20 oil-producing companies to dispose of salt water in oil well operation at Santa Fe Springs, Cal. Waste water enters plant with oil content of 400 to 500 p.p.m., and when discharged contains only about 12 p.p.m. Emulsified oil amounts to only 0.5 percent of oil present but its removal requires disproportionately large expenditure, about one-half of the area of the plant being devoted to this function. It was found that if minute particles held in suspension could be brought to surface in tank with water surface free from any trace of oil they would there break up into a thin iridescent film that would spread over surface. Plant was therefore designed so that after floating oil had been entirely removed the apparently clear waste water would be passed in thin stream over riffled ramp, riffles being constructed so that after passing over each successive ridge the water would fall to surface of concrete ramp below, thus receiving maximum aëration. In the compartment below, the suspended particles rise to surface slowly but continuously and collect as thin scum which can be readily skimmed off in usual manner. Plant consists of series of gravity flow rectangular concrete tanks below ground level arranged successively for aëration, sedimentation, preliminary oil skimming, reaëration and agitation by means of riffle overflow, and secondary oil skimming, an excelsior filter and an 18 to 24-inch vitrified clay discharge line, 81,000 feet long, to ocean. Aëration is effected by series of horizontal racks or grillages made of parallel strips of wood. Grillages are 1 foot apart, strips in each one being at right angles to those in preceding grillage. Sedimentation basin, which has

one inclined wall to facilitate settling, removes 99 percent of sediment. Floating oil is removed by "swing pipe" skimming device. Slurry is pumped to nearby pit and oil to storage tanks. Estimated that 200 to 400 barrels of oil will be recovered per day, value of oil being 60 to 75 cents per barrel. Plant has capacity of 70,000 barrels per day. Initial cost ($450,690) was apportioned on basis of output of waste from each plant and operating costs will be apportioned on same basis.—*R. E. Thompson.*

Intake Conduits for Water Works of Hamilton, Ont. H. S. PHILIPS and JAMES STODART. Eng. News-Rec., 102: 787, May 16, 1929. First source of supply (1859) of Hamilton was an infiltration basin on shore of Lake Ontario connected to pumping station by 38-inch wood-stave conduit. In 1912–3 a 48-inch steel conduit was laid from basin 2144 feet into lake and a 48-inch concrete line from basin to pumping station. Almost complete stoppage of the 48-inch intake pipe in 1923 resulted in abandonment of the infiltration basin, joining of the two 48-inch pipelines constructed in 1912–3 and construction of new steel intake conduit 60 inches in diameter. Details of construction of intake conduits are included. The 60-inch line was fabricated on shore in 24 lengths each about 126 feet long. Plates were ½ inch, with double-riveted longitudinal and single-riveted circumferential joints. Five cast iron flexible joints were provided. Each 126-foot length is supported on 3 pipe bents, with rolling blocks bolted to the caps. Where trench fill was over 6 feet deep, pipe was incased in 12 inches of 1:3:5 concrete. Crib for new intake conduit is 22 feet in diameter, and was built of interlocking sheet piling, being assembled on scow, floated to position and lowered by derrick scow. It rests on shale. There are 6 intake ports, each with area of 54 square feet, designed to give velocity of 1.45 second-feet at time of maximum draft. Velocity in 60-inch conduit is 4.7 second-feet.—*R. E. Thompson.*

Cableway Carries 5-Ton Load Across Span of 2295 Feet. LESLIE W. STOCKER. Eng. News-Rec., 102: 793–4, May 16, 1929. Illustrated description of cableway across Tuolumne Canyon, designed for maximum hook load of 5 tons, employed for transporting, men and materials to Foothill Division Tunnel of Hetch Hetchy project.—*R. E. Thompson.*

Aërial-Tramway Development for Construction Haulage. M. P. MORRISON. Eng. News-Rec., 102: 856–60, May 30, 1929. Discussion of aërial transportation systems, possibilities and economies of which are demonstrated in the two dam construction tramways—Coolidge and Pardee—described in this article.—*R. E. Thompson.*

Water for Hendersonville from Pisgah National Forest. PRESON P. PHILLIPS. Eng. News-Rec., 102: 713–4, May 2, 1929. United States Dept. of Agriculture, which has charge of all national forest areas, considers the use of these areas for public water supply to be of great importance. Details are given of permits by which Hendersonville, N. C., derives water supply from Pisgah National Forest and of the impounding works which have been constructed. Area of 24 square miles of well-forested land having annual rainfall

of about 60 inches has been allotted to city. Present development contemplates only gravity supplies from points well up toward heads of creeks, but by building impounding dams at lower points this area can be made to yield up to 20 m.g.d. Drainage areas are protected by sanitary and fire protection regulations of Forest Service and water requires no treatment. Chlorination is, however, employed.—*R. E. Thompson.*

Simplified Method of Calculating Volumes of Retaining Walls. Wm. F. Covil. Eng. News-Rec., 102: 765, May 9, 1929. Formulas given for calculating volume of retaining walls which vary in height throughout length while top width and slope of faces remain constant.—*R. E. Thompson.*

Building a Lock and Dam on the Illinois. Sutton Van Pelt. Eng. News-Rec., 102: 778–82, May 16, 1929. Illustrated description of construction of Starved Rock lock and dam, the third to be completed of 5 similar structures being built to provide slack water navigation from Chicago Drainage Canal down Des Plaines and Illinois Rivers to Mississippi.—*R. E. Thompson.*

Manganese in the Water Supplies of the Rhine Province. Karl Kisskalt. Arch. Hyg., 99: 96–8, 1928. From Chem. Abst., 23: 224, January 10, 1929. Manganese has been found in appreciable quantities in drinking water in 2 regions of lower Rhine province.—*R. E. Thompson.*

Small-Bore Tunnel Driving in New England. Eng. News-Rec., 102: 951–6, June 13, 1929. Extensions of water supply systems of New Haven and Waterbury, Conn., and Springfield, Mass., involve construction of 6 aqueduct tunnels. The tunnels and tunneling conditions are described and the methods of drilling, mucking, and lining are compared. Concrete lining of all tunnels was placed by pneumatic placing machines. New Haven (Eng. News-Rec. 101: 391, September 12, 1928) and Springfield (Eng. News-Rec., 101: 124, July 26, 1928) tunnels have been previously described. Shepaug tunnel of Waterbury's new development, 7¼ miles long, taps 37-square-mile watershed on Shepaug River, carrying water to present system in West Naugatuck Valley. It has 3-foot vertical sidewalls and semicircular arch of 3-foot radius. Future plans call for storage reservoirs at each end of tunnel, but at present a concrete diversion dam across Shepaug River and existing Morris reservoir will suffice. Another tunnel, known as Steele Brook, a trifle more than a mile in length, is being driven as part of new pipe line from Morris reservoir to city.—*R. E. Thompson.*

Pipe Welding and Laying Methods on 250-Mile Gas Line. Eng. News-Rec., 103: 54–7, July 11, 1929. Illustrated description of construction of 16-, 20-, and 22-inch line under way by Pacific Gas and Electric Co. Line is a completely welded, high-carbon steel tube laid with minimum cover of 2 feet. About 50 percent is wrapped and remainder, on higher ground, is painted only. Field wrapping was carried out by machine designed to wrap the 30-foot lengths, first with tarred felt coated on both sides with asphaltic paint and then with paper to prevent sticking. Machine has capacity of 10,000 linear feet of

20-inch pipe in 8 hours. Wrapping, including felt and paint, weighs about 2.5 pounds per square foot in place. Acetylene welding, mainly, is being employed. Daily output is 3 to 6 welds per man. Welds are required to be 1 inch wide and to rise ⅛ inch above pipe surface.—*R. E. Thompson.*

Many-Purpose Water Treatment Plant for Beverly Hills, Cal. Eng. News-Rec., 102: 936–8, June 13, 1929. Beverly Hills recently sank wells some 300 to 600 feet within its own boundaries and built a 5-m.g.d. treatment plant for purifying the water therefrom. Well water has a hardness of 12 to 20 grains per gallon and hydrogen sulfide content of up to 20 p.p.m. It contains particles of free sulfur and sulfides, with attendant beggiatoa, and also iron and manganese compounds, accompanied by crenothrix and manganothrix. A 70,000-gallon per day experimental plant was first constructed at cost of $5,700 and operated for period of 5 months. Purification process found most suitable and finally adopted consists of aëration, lime treatment, mechanical filtration, and chlorination. Aëration with Sacramento-type spray nozzles set 4 feet above sloping floor over which water trickles to depth of 0.5 inch was found to give best results. Aëration chamber is entirely enclosed, liberated gases being carried off by stack 130 feet high, a pressure oil-burner in base creating the necessary draft. Softening was not at first considered owing to high consumption, mean annual rate being 225 gallons per capita daily, and summer rate, 345 gallons, with peak days of 415 gallons. Tests, however, showed that 40 to 50 percent softening could be effected at cost of less than 1 cent per 100 cubic feet. It has been found that lime also aids flocculation of alum and increases length of filter runs. Wash water was reduced from the 5 percent required when alum alone was applied to 2.66 percent, by using 8.56 grains of lime with the 1.06 grains of alum per gallon. There are 2 series of mixing tanks, each consisting of 4 units 12 feet in diameter and 20 feet deep, equipped with variable-speed mechanical agitators operating at 13 to 20 r.p.m. Retention time averages 5 minutes per tank. From first series of mixing tanks water flows to primary settling tank, 60 feet in diameter, with revolving sludge scrapers, providing retention period of 1 hour; then through secondary mixing tanks to 96 by 130-foot sedimentation basin, 14 feet deep, in two compartments, with total capacity of 5 million gallons and retention period of about 6 hours. There are 5 sand filters arranged in 2 half-sections each 9 by 20 feet in plan. Sand has effective size of 0.4 mm. and uniformity coefficient of 1.4, and underdrains are of 2-inch seamless brass tubes, 9 inches center to center, with ¾-inch holes 6 inches apart in single row in bottom. Wash water is supplied from two 57,000-gallon tanks on fourth floor of building. Trouble was experienced with mud balls in filter beds, and disagreeable odor was given off during backwashing. Analysis of mud balls showed them to contain 80 percent sand and 20 percent soluble lime and organic matter. Of latter, 0.3 percent was iron and 0.1 percent manganese. At this time 0.5 p.p.m. chlorine was being applied to filter influent. Dosage was increased to 1 or 2 p.p.m. without getting more than trace of chlorine in effluent. Each filter was then treated separately as it was taken out of service for washing. After backwashing in usual way the standing water in the filter was chlorinated by submerging discharge hose of portable chlorine injector and dragging it around to obtain

uniform distribution, until dark brown color was obtained with *o*-tolidin. Rewash valve was left open until water from bottom of filter gave same reaction, showing that whole bed had been treated uniformly. Water was then allowed to remain in filter 24 hours, after which filter was drained and again washed in ordinary manner. After one such treatment the bad odor and the organic formation on sand disappeared, filter runs increased and practically all mud balls disappeared. Three weeks after first filter was treated, mud balls and odor were again noticed. Filters were treated as before and after second treatment only very few small mud balls remained. Rough measurements indicated that chlorine dosage employed was 15–20 pounds per million gallons. Total cost of plant was $240,000 and operating cost, excluding capital charges, totals 2.28 cents per 100 cubic feet. Questionnaire has shown that proportion of consumers using bottled drinking water has been reduced from 85 percent prior to construction of plant to 45 percent. This saving exceeds cost of plant operation.—*R. E. Thompson.*

Motor Truck for House-Connection Gangs, Richmond, Virginia. G. W. JAMES, JR. Eng. News-Rec., 102: 1025, June 27, 1929. Illustrated details given of motorized plumber's truck employed for distributing material to city gangs laying water and gas services in Richmond.—*R. E. Thompson.*

Feeding Chlorine through Long Pipe Proves Satisfactory. AUGUST V. GRAF. Eng. News-Rec., 102: 938, 1929. Chlorination of the settled water at the Chain of Rocks plant, St. Louis, was begun in October, 1927, the Cl_2 being introduced at point of application of the secondary coagulant at the north end of the filter plant, a distance of 800 feet from the unloading floor. To avoid transporting the cylinders this distance a room was built on the unloading floor and 6 batteries of 8 cylinders were connected to manifolds, which in turn were connected to a $\frac{3}{4}$-inch galvanized pipe which conveys the chemical to the chlorinators at the north end of the plant. Liquefaction of the Cl_2 in passing through the pipe gallery, where the temperature is always low, has been eliminated by the installation of a reducing valve in the line in the Cl_2 room and by maintaining pressure of less than 100 pounds per squre inch.—*R. E. Thompson (Courtesy Chem. Abst.).*

Buggy Gives Painters Easy Access to Small Steel Water Pipes. O. G. GOLDMAN. Eng. News-Rec., 102: 942, June 13, 1929. Through use of rubber-tired buggies on which a man can lie and propel himself inside pipe, Spring Valley Water Co., San Francisco, has solved difficult problem of completing inside protecting paint coat at joints of steel water pipes from 16 to 36 inches in diameter. Buggy has been used successfully to enter pipe lines as far as 1000 feet, and grades of about 20 percent have been traversed. No ropes are used, buggies being propelled entirely by the feet. Men are sent into pipes in pairs, each on buggy, using flashlights for illumination, first man wire-brushing the joints and second doing the painting. Illustrated.—*R. E. Thompson.*

Administration Building of York Water Company. EDGAR P. KABLE. Eng. News-Rec., 102: 950, June 13, 1929. New 2-story administration building of York Water Co., York, Pa., 40 by 140 feet in plan, is described briefly and illustrated.—*R. E. Thompson.*

Grover Cleveland Tank and Tower, Buffalo Water Works. FREDERICK W. WANZEL. Eng. News-Rec., 102: 939–41, June 13, 1929. One concrete tower supports and another encloses new steel water tank located in Grover Cleveland Park, Buffalo. Interesting feature of construction was use of 2 sets of forms, one inside other, lifted simultaneously; and erection of steel tank after supporting and encircling towers had been built. Tank was made necessary by rapid growth of residential section. Governing conditions of design were: maximum water head of 120 feet; tank capacity of 0.25 million gallons; monumental design. Cost was $77,071. Details of design and architecture illustrated.—*R. E. Thompson.*

Steel Standpipe Enclosed by Wall at Falmouth, Mass. EDWARD B. RICHARDSON. Eng. News-Rec., 102: 941–2, June 13, 1929. Conspicuous location chosen for new standpipe in Woods Hole residential section of Falmouth necessitated erection of ornamental structure. Reinforced-concrete enclosing shell added $18,900 to the $12,300 cost of steel standpipe with foundation and gate chamber. Standpipe is 26 feet in diameter and 90 feet high, capacity being 0.32 million gallons. There is clear annular space of 2 feet between standpipe and enclosing tower, which are independent of each other except that annular space is roofed by steel plates fastened rigidly to standpipe and loosely to concrete wall.—*R. E. Thompson.*

Detroit Water Board Builds for Itself and Other Departments. GEO. H. FENKELL and D. C. GROBBEL. Eng. News-Rec., 102: 949, June 13, 1929. Brief illustrated description of office building erected by Detroit Board of Water Commissioners at cost of $1,454,432. Building consists of basement, 20 stories of office space, and 3 stories of pent house, the first 9 stories being reserved for the board and remainder rented to other city departments.—*R. E. Thompson.*

Water Consumption Varies with Standards of Living and Fluctuations in Industrial Conditions. ABEL WOLMAN. Eng. News-Rec., 102: 943–8, June 13, 1929. Extensive data on per capita consumption in 44 American and European cities, 1907 to 1927, are tabulated, shown graphically, and discussed. Per capita water consumption is affected by varied and numerous factors. This article is devoted particularly to the effect of one factor, "standard of living," which has probably received least consideration in other water consumption studies. Conclusions: (1) There is general tendency for per capita water supply use to rise with industrial prosperity and to fall with industrial depression. General trend is independent of such restrictive measures as metering and high rates, and in many instances effect is of greater magnitude than more commonly accepted causes of variation. (2) Effects of industrial conditions are greater than are those of increasing population alone. It is believed that effect of population increase in increasing per capita use has been over estimated, except insofar as population increase reflects industrial expansion and prosperity. (3) Actual water use per person per day for domestic purposes is 2–3 times as great in United States as in foreign countries. There

is evidence to indicate that this difference is not wholly one of waste or extravagance, but probably has its origin in fact that standard of living and demand for sanitary facilities have reached higher level in United States than elsewhere.—*R. E. Thompson.*

Laying 20- to 60-Inch Riveted Steel Pipe in the Greater Vancouver Water District. F. C. STEWART. Eng. News-Rec., 102: 960–3, June 13, 1929. Within past 4 years Greater Vancouver Water District has laid over 20 miles of 20- to 60-inch riveted steel pipe varying in thickness from $\frac{1}{4}$ to $\frac{9}{16}$ inch. General features of design are outlined and ffeld methods employed are described in detail and illustrated.—*R. E. Thompson.*

New 20-M.G. Clear Water Reservoir for Detroit Water Works. EUGENE A. HARDIN. Eng. News-Rec., 103: 8–9, July 4, 1929. Studies made in 1925 (cf. this Journal, 16: 582) of economical ratio of filtered water storage to filter capacity at Detroit indicated that plant capacity could be materially increased by adding 20 million gallons to existing 35 million gallons storage. New reservoir is about 300 x 476 feet in plan and has maximum water depth of 20 feet. Entire structure is of reinforced concrete of usual design, including flat-slab roof. Latter is protected by 20 inches of earth on 6-inch drainage layer of open stone and was designed for total imposed load of 500 pounds per square foot. Side walls were designed as vertical slabs supported at top and bottom, with bottom completely fixed to insure watertightness. Reservoir rests on timber piles averaging about 30 feet in length. Main drains lead into 2 small pump chambers in which float controlled sump pumps keep ground water level down to few feet above floor line to prevent possibility of flotation when reservoir is emptied. Modern methods of concrete mixing were employed throughout. All construction joints were provided with ample keyways and all vertical joints were provided with copper water stops. Tests after completion showed less than 100 gallons per minute leakage from entire structure when full.—*R. E. Thompson.*

Remodeling Pumping Station of Willimantic Water Works. HENRY W. TAYLOR. Eng. News-Rec., 102: 958–9, June 13, 1929. Willimantic, Conn., a city of 13,000 population, derives water supply from Natchaug River, intercepting its flow at power dam behind which lies drainage area of about 180 square miles. Original pumping equipment consisted of 2 units, one driven by steam and other by waterwheel. These units were later supplemented by second waterwheel-driven pump. Recent improvements include installation of new water-driven pump, removal of older and now obsolete waterwheel pump, remodeling of tail-race conditions to give freer escapement from draft tube, and repair of newer pump. Improvements have rendered use of steam pump unnecessary, saving former annual coal cost, which amounted to $3,700.—*R. E. Thompson.*

Winter Construction of Concrete Bridge, Springfield, Mo. WILLIAM JUDSON GRAY. Eng. News-Rec., 102: 995–6, 1929. An illustrated description of winter construction methods employed by the Springfield City Water Co. in

erecting a concrete highway bridge over a large reservoir. Quick hardening cement, ground limestone, and heated mixing water were used and the concrete was protected by tarpaulins and salamanders. The forms were removed after 72 hours. It was found during the construction of the dam forming the reservoir that concrete made with ground limestone as fine aggregate was dense and almost impervious and had compressive and tensile strength far exceeding that of concrete made with river sand. The finished concrete is snow white in appearance, close grained, and almost resembles granite.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Spun Concrete Pipe Conveys Water Supply Under 145-Foot Head. H. HAWGOOD. Eng. News-Rec., **102**: 1023–5, June 27, 1929. Concrete pipe line 48-inches in diameter, designed for maximum working head of 145 feet, was recently put in service by Escondido Mutual Water Co. in Southern California, replacing 20-inch steel line laid in 1914. New line, which is part of extensive improvements to meet increasing water and power demands and also to convey water for San Diego County Water Co. is of centrifugally processed concrete pipe and is 2510 feet long. Lake Wholford, where water is stored, has storage capacity of approximately 7500 acre feet. Pipe line was laid along steep rocky mountain side in 8-foot lengths, 4 inches thick. Curves, laid on centerline radius of 120 feet, constituted 22.4 percent of total length. Pipe was made by HUME process in Los Angeles and hauled by truck and trailer. Calked dry joints were selected. It is doubtful whether water penetrates far, if at all, into this type of joint, if well made. Line has been operated up to 82 percent of maximum head and no leakage has developed. First cost of 50-inch steel pipe would have been less than the 48-inch concrete pipe, but latter was chosen primarily because of its longer life.—*R. E. Thompson.*

Difficult Tunnel and Bridge Work on French Mountain Railway. Eng. News-Rec., **103**: 9–10, July 4, 1929. Brief data given on tunnels, of which there are about 40, up to 3¾ miles in length, constructed on line built by Paris, Lyon, and Mediterranean Railway, France. Serious troubles were caused by presence of calcium sulfate in rock, which absorbed moisture on exposure to air and expanded to such extent as to require very heavy masonry lining to resist pressure. Furthermore, in contact with water the gypsum would dissolve, decomposing the mortar in the masonry and forming large cavities around tunnel. Foundations were carried into dry gypsum and an alumina cement used which would not be affected by the gypsum. Extensive drainage work was carried out to prevent swelling by absorption of water, and in one tunnel tar was injected to fill or coat voids behind tunnel.—*R. E. Thompson.*

High-Head Power Plant of 120,000-Hp. Capacity Nearing Completion in Scotland. Eng. News-Rec., **103**: 11–4, July 4, 1929. Illustrated description of Lochaber development, which includes reservoir formed by 3 dams up to 45 feet in height and 15-mile tunnel with cross-section of 181 square feet inside concrete lining, equivalent to 15-foot circle. Tunnel line intersects a number of streams which do not flow into main reservoir system and arrangements have been made to tap these streams by 11 vertical shafts. In flood time part

of water thus collected, by reason of greater head, flows back up tunnel to reservoir system. Hydraulic characteristics of tunnel design were analyzed by REGINALD S. COLE in paper "The Surge Chamber in Hydro-Electric Installations" (Inst. Civil Eng., Paper No. 55: 1927). Work is proceeding by modified heading and bench method at 23 headings. For greater part of work, liquid oxygen cartridges are being used, gelignite being employed for remainder.—*R. E. Thompson.*

Chlorine Control for a Small Direct-Pressure Water System. EARNEST BOYCE. Kansas State Bd. of Health, Lawrence. Eng. News-Rec., **102**: 1042, 1929. A brief description of the Cl_2 control adopted for a small supply (0.25 m.g.d.) in Kansas obtained from an infiltration gallery and pumped directly into the mains. A small concrete well was constructed which serves both as a mixing tank for the Cl_2 and as a suction well for the centrifugal pump. The water flows from the infiltration gallery into the well at a constant rate, controlled by a fixed orifice with constant, but manually controllable, head, slightly in excess of the maximum pumping rate and an overflow is provided to waste the difference between the inflow and the amount being pumped into the mains. This arrangement permitted the installation of a relatively less expensive type of chlorination equipment.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Slag Backfilling Gives Good Results at Saving in Cost. W. C. HAWLEY. Eng. News-Rec., **102**: 1041, June 27, 1929. Difficulties in backfilling trenches opened in modern pavements have been overcome in district surrounding Pittsburgh, Pa., by use of pulverized slag. After pipe has been laid a small amount of earth is thoroughly tamped around and above it and then excavation is refilled with slag in 2 to 4-inch layers, wetted and thoroughly rammed. In day or two paving may be placed on slag, which sets up like concrete, although not so hard that it cannot be excavated with pick and shovel if necessary. Expense of disposing of excavated material is offset by fact that it is not necessary to return 2 or 3 times to relay pavement after backfill has settled. Use of slag is limited by cost. In Pittsburgh district it can be obtained in carload lots for the freight. Investigation has shown that sulfur in slag is in insufficient quantities to cause damage to pipes.—*R. E. Thompson.*

Biological Purification of Creamery Wastes. MAX LEVINE. Ind. Eng. Chem., **21**: 1223–5, 1929. The development of germicidal or inhibitory acidities, due to anaërobic decomposition of lactose, is responsible for the disruption of the protein digestion activities of bacteria in septic and Imhoff tanks. Oxidation of the lactose is accomplished by use of a lath filter, the first two feet of which effected a reduction of over 90 percent of the sugar in skim milk solutions containing from 1700 to 3250 p.p.m. thereof. A waste which remains neutral or alkaline on anaërobic storage will not interfere with septic action in municipal sewage plants.—*Edward S. Hopkins* (*Courtesy Chem. Abst.*).

Study of the Floc Produced by Chlorinated Copperas. EDWARD S. HOPKINS. with EUGENE R. WHITMORE. Ind. Eng. Chem., **22**: 79–81, 1930. Laboratory

experiments, using simulated plant conditions, show that chlorinated copperas is a satisfactory coagulant, comparable in this respect to alum. At any pH value above 3.5, it is an efficient coagulant for turbid waters, the precipitation of the iron being practically complete. This floc is capable of removing organic coloring matter from highly colored waters. Manganese is not completely removed at pH values less than 9.4. A theoretical discussion of the composition of the floc is given.—*Edward S. Hopkins* (*Courtesy Chem. Abst.*).

Ferric Alumina. A. R. MOBERG and E. M. PARTRIDGE. Ind. Eng. Chem., **22**: 163–4, 1930. A discussion of theoretical reasons why a new coagulant should be developed. "Ferric Alumina," essentially a colloidal sol of hydrous alumina peptized by addition of ferric chloride, is the new coagulant. Removal of appreciable color colloidal particles contaminating river water was obtained by it.—*Edward S. Hopkins* (*Courtesy Chem. Absts.*).

Pollution Studies of Upper Mississippi River. F. L. WOODWARD. Ind. Eng. Chem., **22**: 189–92, 1930. A review of the work of the Minnesota State Board of Health, The Minnesota Department of Conservation, the Wisconsin State Board of Health, and the Metropolitan Drainage Commission of Minneapolis in studying the pollution of the Mississippi River from Minneapolis, Minnesota, to La Crosse, Wisconsin.—*Edward S. Hopkins* (*Courtesy Chem. Absts.*).

Baldwin Filtration Plant, Cleveland, Ohio. J. W. ELMS, G. W. HAMLIN, A. G. LEVY, and J. E. A. LINDERS. Proc. Am. Soc. Civ. Engrs., **56**: 2, 201–260, February, 1930. This article presents a detailed description including plans and tables of the design, construction, and equipment of the $10,000,000 165,000,000-gallon Baldwin Filtration Plant, Cleveland's second, and the 135,000,000-gallon covered concrete reservoir, which with the 150,000,000-gallon Division Filtration Plant is capable of supplying the entire city and its principal suburbs with filtered water at least until 1930. The subject is considered under the following headings: History and Development of the Project; General Description of Flow of Water; Hydraulic Data: Design; Construction; General Equipment; Completion of Baldwin Filtration Plant; and amount of Contracts and Analysis of Costs. Unusual features of this project are: the hydraulic-jump mixing flumes: the design of the coagulation basins to provide a straight flow through them with no baffles; the use of a sharply sloping floor in the coagulation basins to reduce the height of the outside walls and facilitate the clearing of the basins; and the method of introducing water to the reservoir and drawing it off in order to provide good circulation. Of special interest are the complete tables of costs. The design provides for 40 filter beds at 125,000,000 gallons per acre per day filtration rate, with alum treatment at one grain per gallon.—*Isador W. Mendelsohn.*

Hughes Reports to Supreme Court on Chicago Diversion. Eng. News-Rec., **103**: 983, December 19, 1930. Acting as a special master appointed by the United States Supreme Court, CHARLES EVANS HUGHES on December 17 submitted a report to that body recommending that it order the construction in

Chicago of a series of sewage treatment plants over a period of 9 years and the simultaneous reduction, by degrees, of water diversion from Lake Michigan from the present amount of 8,500 second-feet to a permanent figure of 1500 second-feet on December 31, 1938. The cost of the program is estimated at approximately $176,000,000. The report, prepared after hearing the testimony for the city of Chicago and the Sanitary District of Chicago on the one side and the states bordering the Great Lakes on the other, is the result of 3 separate suits initiated by the complainant states claiming that the diversion has had a detrimental effect on navigation conditions. Important recommendations, in addition to those dealing directly with the construction of sewage disposal works, include: (1) That the diversion by the Sanitary District from Lake Michigan should be reduced on July 1, 1930, to an annual average of 6,500 second-feet, in addition to domestic pumpage. (2) That, subject to the approval of the Secretary of War, upon the recommendation of the Chief of Engineers, controlling works should be constructed by the Sanitary District within 2 years after receiving authorization, for the purpose of preventing reversals of the Chicago River at times of storm and the introduction of storm flow into Lake Michigan. (3) That when such controlling works have been constructed, the diversion should not exceed an annual average of 5,000 second-feet in addition to domestic pumpage. (4) That there should be provision in the decree for an appropriate examination of results from time to time as the work of sewage treatment progresses, to the end that there may be such further reductions of the diversion as may be found to be feasible pending the completion of the sewage treatment works. (5) That, after addition of controlling works and on completion of all the sewage treatment works, and in the absence of competent action by Congress in relation to navigation law fully imposing a different requirement, the diversion should not exceed an annual average of 1500 second-feet in addition to domestic pumpage. At the present time Chicago is drawing 8,500 second-feet of water from Lake Michigan and sending this through the Chicago and Illinois rivers to be discharged down the Mississippi. This is being done under the authority of a War Department permit which expires December 31, 1929. Application has been made for an extension of this permit, and it is believed that this will be granted pending a final ruling of the Supreme Court based upon the master's report.—*R. E. Thompson.*

NEW BOOKS

Report of Bureau of Sanitary Engineering, Maryland State Department of Health, 1929. ABEL WOLMAN. 16 pp. (Mimeographed.) A report on the activities of the Bureau during 1929. Only 67 deaths from typhoid occurred in Maryland in 1929, the lowest number in the history of the State, compared with 556 in 1910. The death rate for the entire State was 4.2; for Baltimore City, 3.2; and for Maryland, exclusive of Baltimore, 5.2 per 100,000. This record demonstrated anew that it is possible to reduce the morbidity and mortality from typhoid in semi-urban and rural populations. During the past year, $4,900,000 were spent in the State for sanitary works, of which $3,335,000 were spent in the City of Baltimore. Regulations governing public swimming pools

were adopted by the State Board of Health on June 18, 1929. Revised detailed operating regulations are now in preparation and probably will be placed in effect in the spring of 1930. A large number of much needed additions and extensions to existing sanitary installations of the State institutions were carried out during the year, this work having been made possible by appropriations by the 1929 Legislature. The number of State institutions at which the Bureau has assumed direct supervision of the operation of the water and sewage treatment plants was increased during the year from 4 to 9. An engineer of the Bureau devotes his full time to this work. Each institution contributes a small sum annually, varying from $250 to $600, to meet the expenses in connection with the work. Improvement has been noted both in the plants and in the attitude of the operators since this plan has been in effect. Installation of a zeolite softening plant at one institution has improved boiler operation and reduced soap consumption 30 percent. Detailed surveys of the efficiency and depreciation of the water filtration plants throughout the State were begun during the year. Although this study has not been completed, much valuable new information has already been obtained. Continued efforts on the part of the Bureau at a congoleum plant have resulted in the development of a new process for reducing the amount of waste which involves the recirculation of all the waste water, the net saving effected amounting to about $46,000 per year. Studies on the disposal of laundry wastes have indicated that treatment with 15 g.p.g. of sulfuric acid and 7.2 g.p.g. of ferrous sulfate would produce a satisfactory effluent with a minimum of expense and no operating difficulties. Tabulations are appended showing the typhoid mortality statistics and the activities of the Bureau during 1929.—*R. E. Thompson.*

The Purification of The Water of Swimming Baths. Ministry of Health. H. M. Stationery Office (London). Paper 52 pages. Price 1s.0d. net. The history of swimming baths is sketched from the eighteenth century to date although the earliest known pool in Britain was in Bath in the first century A.D. The ruins of this pool are still preserved, being fed by its original and perennial source which needs neither purification nor heat. This century has has seen an immense increase in popularity of swimming, and in the demand for swimming facilities, and the provision of such facilities still lags painfully behind the times. **Pollution in Swimming Baths.** This section is divided into three parts: (*a*) Sources not derived from the Persons of the Bathers; (*b*) Pollution from the Persons of the Bathers, and (*c*) Bacterial Pollution of Swimming Baths. An account is given of the filling of a pool with polluted sea water which resulted in an epidemic of enteric fever. **Transmission of Infection by the Water of Swimming Baths.** The evidence that various diseases are occasionally, though infrequently, transmitted by waters in swimming baths appears convincing. These are gastro-intestinal infections, respiratory infections, skin infections, eye infections, and nasopharyngeal infections, the last two groups being the most numerous and important. **Methods of Purification of Bath Water.** Constant flow, natural purification, fill-and-empty without treatment and chemical treatment without filtration are discussed in this section. **Purification by Continuous Filtration.** To be

effective the water should be circulated continuously while the pool is in use. Adverse impressions on the results obtained with filters may generally be traced to the period of turnover being too long. Various formulae have been put forward for calculating the turnover period but they do not appear successful in practice. For indoor pools which are largely frequented a turnover period of not more than four hours will keep the water clean during peak loads. The continuous filtration process, use and method of applying coagulants, filters, filter washing, wash water, rate of filtration, re-heating and aëration are covered. **Chlorination.** Continuous chlorination is considered essential, the amount of chlorine applied being regulated by keeping the amount of residual between 0.2 and 0.5 p.p.m. The use of chloramines holds out considerable promise owing to the prolonged effective action which is characteristic of such compounds. This method of disinfection consists of the administration of ammonia gas which is given a short period of contact before the administration of the chlorine gas, the dose of ammonia being usually one-fourth of that of the chlorine. The addition of the ammonia seems to increase not only the efficiency of the chlorine, but the length of time during which it is able to produce its disinfecting action, and the method seems one less liable to produce complaint than the simple administration of chlorine. Comparative figures obtained by Mr. Joseph Race, F. I. C., on the treatment of sewage and swimming pool water by chloramine and chlorine are given. **Alkalinity.** "The provision of apparatus for measuring the right degree of alkalinity is as necessary for the successful working of the filters with respect to clarity, as is the provision of apparatus for measuring the free chlorine with regard to bacteriological purity." **Other Details of the Continuous System.**—Inlets for the filtered water; meters and gauges; guarantees of the efficient working of filter plants; cleansing of the bottom of the pool; prevention of pollution entering the pool and surroundings.—This is an excellent and comprehensive treatise on the swimming pool and one worth having.—*A. W. Blohm.*

Water Softening: The Base-Exchange or Zeolite Process, Summary of Existing Knowledge. A. R. MARTIN. Department of Scientific and Industrial Research—Water Pollution Research, Technical Paper, No. 1. H. M. Stationery Office. London, England. Price 6d. net. This booklet gives a summary of the existing knowledge of the base-exchange or zeolite process of water softening. Includes theory, constitution and nature of base exchange silicates and bibliography.—*A. W. Blohm.*

Colorado, Wyoming, Utah, California, and Arizona: Colorado River. Surface Water Supply of United States, 1925: pt. 9, Colorado River Basin. NATHAN C. GROVER, chief hydraulic engineer, ROBERT FOLLANSBEE, A. B. PURTON, and W. E. DICKINSON, district engineers. 1929. U. S. Geol. Survey Water Supply Paper **609.**—*Arthur P. Miller.*

Colorado River. Suspended Matter in Colorado River in 1925–28. C. S. HOWARD. 1929. U. S. Geol. Survey Water Supply Paper **636-B.**—*Arthur P. Miller.*

Utah, Nevada, California, Oregon, Idaho, and Wyoming: Great Basin. Surface Water Supply of United States, 1925, pt. 10, Great Basin. NATHAN C. GROVER, chief hydraulic engineer, A. B. PURTON, H. D. MCGLASHAN, F. F. HENSHAW, C. G. PAULSEN, and ROBERT FOLLANSBEE, district engineers. 1929. U. S. Geol. Survey Water Supply Paper **610.**—*Arthur P. Miller.*

Texas and Colorado: Gulf Coastal Plain. Surface Water Supply of United States, 1925, pt. 8, Western Gulf of Mexico Basins. NATHAN C. GROVER, chief hydraulic engineer, C. E. ELLSWORTH, and ROBERT FOLLANSBEE, district engineers. 1929. U. S. Geol. Survey Water Supply Paper **608.**—*Arthur P. Miller.*

Missouri, Colorado, Kansas, and Texas: Mississippi River. Surface Water Supply of United States, 1925, pt. 7, Lower Mississippi River Basin. NATHAN GROVER, chief hydraulic engineer, H. C. BECKMAN, ROBERT FOLLANSBEE, H. B. KINNISON, and C. E. ELLSWORTH, District engineers. 1929. U. S. Geol. Survey Water Supply Paper **607.**—*Arthur P. Miller.*

Oregon and Washington: Pacific States. Surface Water Supply of United States, 1925, pt. 12. North Pacific Slope Drainage Basins, C. Pacific Slope Drainage Basins in Oregon and Lower Columbia River Basin. NATHAN C. GROVER, chief hydraulic engineer, F. F. HENSHAW and G. L. PARKER, district engineers. 1929. U. S. Geol. Survey Water Supply Paper **614.**—*Arthur P. Miller.*

Idaho, Oregon, Nevada, and Washington: Snake River. Surface Water Supply of United States, 1925, pt. 12. North Pacific Slope Drainage Basins, B, Snake River Basins. NATHAN C. GROVER, chief hydraulic engineer, G. C. BALDWIN, G. L. PARKER, C. G. PAULSEN, A. B. PURTON, and F. F. HENSHAW, district engineers. 1929. U. S. Geol. Survey Water Supply Paper **613.**—*Arthur P. Miller.*

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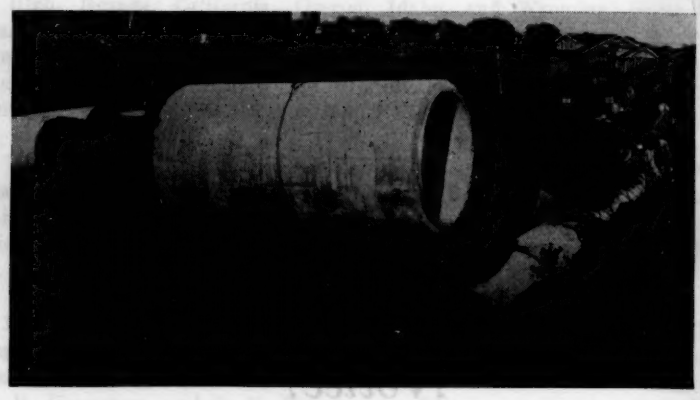

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